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TRANSACTIONS

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Volume VII

Edited by

CARLETON REA and J. RAMSBOTTOM

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The President and Secretary of the Society *ex Officio*.

THE MINEHEAD FORAY.

September 27th to October 2nd, 1920.

The twenty-fourth annual meeting and autumn foray took place at Minehead, Somersetshire from September 27th to October 2nd, 1920. As usual most of the members assembled on the Monday and dispersed on the Saturday leaving four clear days for the business of the meeting proper.

A council meeting was held on Monday evening. Amongst other matters it was decided that a day's foray should be arranged for students of London colleges preceded by a semi-popular lecture*; and further, to attempt in some way to clear up the confusion in mycology, due to the many descriptions of new genera which have appeared since the publication of the last volume of Saccardo's Sylloge Fungorum, by reprinting the original diagnoses and to keep up to date by annual lists.

The first excursion was a whole day one to Horner Woods. All of the woods visited are of the same type namely typical *Quercus sessiliflora* woods on Devonian sandstone and marl. The journeys on the first three days were made by motor charabanc. The detailed knowledge of the district possessed by Mr Norman G. Hadden enabled him to suggest the splitting of the party where desirable either from the point of view of individual collecting or of personal comfort. At the starting point *Coprinus flocculosus* was discovered inside an old elm. *Lasiobolus macrotrichus* and *Ascophanus cervarius* were found in quantity, both on red deer dung: Horner Woods is the type locality for the former; the colour of the latter is whitish or pallid when fresh and does not become the "chestnut brown" colour of the original description until it is old†. Other interesting fungi were *Chlorosplenium versiforme*, *Podosphaera myrtillina*, *Thecopsora Vacciniorum*, *Hygrophorus subradiatus* var. *lacmus*, *Coprinus picaceus*, *Clavaria luteoalba*, *Cyphella alboviolascens* and *Merulius tremellosus*. The president was successful in finding *Myriangium Duriaei* on *Chionaspis salicis* on Ash.

In the evening the general meeting was held. Mr Carleton Rea was elected President for 1921, Miss G. Lister and Mr T. Petch, Vice-Presidents, Mr J. Ramsbottom, General Secretary and Miss D. Cayley and Mr F. T. Brooks as members of the Council —the other officers being re-elected.

* The lecture was given on October 22, 1920 at University College, London (at the invitation of Prof. F. W. Oliver) by Mr Somerville Hastings who showed slides of and described the larger fungi likely to be found the following day on the foray at Oxshott.

† See p. 59.

The Treasurer's statement showed the necessity for the increase in the annual subscription from 10*s.* to £1, due notice of which had been given to members. The discussion which followed showed that many present were of the opinion that an even greater increase was advisable, but it was suggested that it would doubtless be more beneficial to the Society if the necessary funds were obtained by increased membership.

The invitation from the Haslemere Natural History Society to hold the Spring Foray at Haslemere at Whitsun, and that from the Worcestershire Naturalists Club to hold the autumn foray at Worcester* were accepted.

Mr W. N. Cheesman was appointed delegate of the Society to the British Association meeting at Edinburgh.

The President paid tribute to the memory and work of Monsieur E. Boudier and Signor P. A. Saccardo who were highly esteemed honorary members of the Society. He proposed that Monsieur N. Patouillard and Professor R. Thaxter be elected honorary members.

It was decided that fraternal greetings be sent to the Société Mycologique de France†, and to couple with them expressions of sympathy on the death of M. Boudier.

On Wednesday a start was made at noon, the mornings being devoted as usual during the rest of the foray to an examination of the previous day's finds. The woods at Selworthy were visited. Just before turning into the woods a number of specimens of *Clavaria stricta* were found in the hedge bottom and a mass of *Hirneola Auricula-Judae* on *Berberis arcuata*. This proved to be the best day of the foray for collecting Basidiomycetes but the district had not had sufficient rain from a mycological point of view. Interesting additions to the list were *Lepiota excoriata*, *Tricholoma columbetta*, *Russula incarnata*, *Poria sanguinolenta*, *Femsjonia luteoalba* and *Septoria thecicola*.

In the evening Mr T. Petch gave his Presidential Address on "Fungi parasitic on scale insects‡."

Porlock woods were visited on Thursday. The most interesting addition was a patch of about 30 specimens of *Geaster fimbriatus*. Owing to the day being wet certain members of

* Sept. 19–24, 1921.

† The following reply was received from M. A. Maublanc, General Secretary of the Société Mycologique de France. "Les membres de la Société Mycologique de France, réunis en séance le 4 Novembre, après avoir pris connaissance de la lettre que vous avez adressée à M. Moreau, me prient de bien vouloir être leur interprète pour adresser à la Société Mycologique anglaise leurs chaleureux remerciements pour le fraternel salut et les vœux qu'elle leur adresse.

Très touchés de la marque de sympathie de leurs confrères d'Angleterre, ils formulent leurs souhaits les plus sincères pour la prospérité de votre Société."

‡ See p. 18.

the party found it more advantageous to devote their attention to microfungi. The district is extremely rich in rust fungi (see Hadden in Journ. Bot. 1920, p. 37) and many of these were found including *Puccinia Moliniae*, *P. Absinthii*, *Milesina Dieteliana*, *M. Blechni* and *Uredo Scolopendrii*. *Pachyella depressa*, *Androsaceus Hudsonii*, *Paxillus panuoides*, *Hypochnus granulosus* (Peck) Burt* and a lavender form of *H roseo-griseus* Wakef. and Pears† were also listed.

Mr Carleton Rea opened the proceedings in the evening with a paper on the genus *Ganoderma* (Karst.) Pat. This genus is characterised by its shining, resinous, laccate crust and coloured, smooth or rough, oval spores which are truncate at the base. The species may be sessile or stipitate, and in this country include *G. lucidum* (Leyss.) Karst., *G. applanatum* (Pers.) Pat. and var. *laccatum* (Kalchbr.) with verrucose spores and *G. australe* (Fr.) Pat. with its var. *vegetum* (Fr.) Romell, and *G. resinaceum* Boud. with smooth spores.

Mr Rea also exhibited a painting by Miss V. Rea of *Phallus imperialis* and showed some "eggs" which had been collected at Blakeney, Norfolk by Professor F. W. Oliver.

Another interesting phalloid sent for exhibition was *Clathrus cancellatus* collected in the Isle of Wight by Mr W. Johnson.

Mr J. Ramsbottom then gave an account of mycorhiza in orchids. A seed of such an orchid as Odontoglossum is undifferentiated except that the cells at the suspensor end are much the larger. If the seed be sown it merely swells: as Bernard showed, however, the seeds germinate readily if sown on a culture of the fungus extracted from the root of the orchid. The fungus passes through the suspensor into the large cells. Rapid division then takes place in the small cells at the antipodal end of the seed. Here the growing point of the stem is laid down and later the growing point of the root. The young root absorbs its way through the tissues of the "protocorm" and emerges at the side without touching the fungus zone, thus being free from hyphae on entering the soil. It has usually reached a length of ·5 cm. before it becomes infected from the soil. Flasks showing Odontoglossum seedlings grown on a commercial scale, a culture of the "fertilising" fungus and a series of microtome sections prepared by the late Mr J. Charlesworth were exhibited.

The President gave a short account of a paper on Indian Polyporaceae by Professor S. R. Bose.

Mr Ramsbottom then exhibited a "yeast" *Medusomyces Givesii* cultivated in tea, and also the Ginger Beer Plant ‡.

On Friday morning the party made the short journey to

* See p. 57. † See p. 57. ‡ See p. 86.

Dunster by train. There were few of the larger fungi to be seen, but *Lepiota nympharum, L. haematosperma, L. Friesii* and *Pleurotus corticatus* were met with. *Kuehneola albida* was not uncommon and *Oidium alphitoides* on Beech and *Helotium moniliferum* were collected. Most members walked back to Minehead along the coast.

At the evening meeting a communication was read from Professor A. H. R. Buller on the audibility of the "puffing" in the larger Discomycetes. A specimen of *Pustularia catinus* was seen to puff and was held to the ear as one does a shell: a distinct sound was heard like that made by steam when escaping from a tiny jet.

A note by Mr St John Marriott on the discharge of the peridiolum in *Sphaerobolus stellatus* stated that the greatest distance to which these had been thrown was twelve inches.

Mr R. Paulson then gave a paper on "The sporulating gonidia of *Evernia prunastri**."

Mr Ramsbottom exhibited pieces of canvas from different war areas showing "diamond spot" caused by *Macrosporium* and *Stemphylium* which was responsible for so much damage to tentage and which is of great economic importance. The methods of treatment which had been advocated to prevent the trouble were briefly commented on and specimens of treated canvas exhibited.

The meeting ended by votes of thanks to Captain Luttrell for permission to explore Dunster and to Mr N. G. Hadden for making the arrangements for the excursions; to the Foray Secretary, Mr A. A. Pearson, and to the President Mr T. Petch.

All the members present contributed in some way or other in the compilation of the following list of species found during the foray. I would express my thanks particularly to Mr Carleton Rea for assistance in the field and to Dr J. S. Bayliss Elliott, Mr C. H. Grinling, Mr N. G. Hadden, Sir H. Hawley and Mr A. A. Pearson for lists of their finds.

M = Neighbourhood of Minehead. *H* = Horner Woods. *S* = Selworthy. *P* = Porlock. *D* = Dunster.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr. *D.*, mappa (Batsch) Fr. *P.D.*, muscaria (L.) Fr. *S.P.*, rubescens Fr. *H.S.*

Amanitopsis vaginata (Bull.) Roze *D.*, fulva (Schaeff.) W. G. Sm. *S.P.*

Lepiota procera (Scop.) Fr. *D.*, excoriata (Schaeff.) Fr. *S.*, Friesii (Lasch) Fr. *D.*, cristata (A. and S.) Fr. *P.D.*, nympharum Kalchbr. *D.*, granulosa (Batsch) Fr. *H.*, amianthina (Scop.) Fr. *H.S.*, sistrata Fr. *P.*, haematosperma (Bull.) Boud. *D.*

Armillaria mellea (Vahl.) Fr. *H.D.*

Tricholoma resplendens Fr. *S.*, flavobrunneum Fr. *H.*, albobrunneum (Pers.) Fr. *H.S.*, rutilans (Schaeff.) Fr. *H.S.*, columbetta Fr. *S.*, terreum (Schaeff.)

* See p. 41.

Fr. *S.*, sulphureum (Bull.) Fr. *S.*, nudum (Bull.) Fr. *D.*, sordidum *D.*, melaleucum (Pers.) Fr. *D.*, grammopodium (Bull.) Fr. *H.*

Clitocybe nebularis (Batsch) Fr. *H.D.S.*, clavipes (Pers.) Fr. *H.S.*, infundibuliformis (Schaeff.) Fr. *S.*, flaccida (Sow.) Fr. *S.*

Laccaria laccata (Scop.) B. and Br. *H.S.P.D.* var. amethystina (Vaill.) B. and Br. *H.S.P.D.*

Collybia maculata (A. and S.) Fr. *H.*, distorta Fr. *H.*, butyracea (Bull.) Fr. *S.*, confluens (Pers.) Fr. *S.*, fusipes (Bull.) Berk. *S.*, radicata (Rehl.) Berk. *P.*, dryophila (Bull.) Fr. *H.S.*

Mycena pelianthina Fr. *P.*, Iris Berk. *H.*, pura (Pers.) Fr. *S.D.*, rugosa Fr. *H.D.*, galericulata (Scop.) Fr. *H.*, polygramma (Bull.) Fr. *S.*, alcalina Fr. *S.*, ammoniaca Fr. *H.*, metata Fr. *S.P.D.*, amicta Fr. *H.*, virens (Bull.) Quél. *S.*, haematopus (Pers.) Fr. *S.H.P.*, galopus (Pers.) Fr. var. nigra Fl. Dan. (Syn. leucogala Cke.) *H.D. S.*, inclinata Fr. *D.*, epipterygia (Scop.) Fr. *D.*, rorida Fr. *P.*, corticola (Schum.) Fr. *S.*

Omphalia grisea Fr. *P.*, fibula (Bull.) Fr. *H.*, var. Swartzii Fr. *P.*

Pleurotus corticatus Fr. *D.*, petaloides (Bull.) Fr. *P.*, subpalmatus Fr. *H.*

Hygrophorus pratensis (Pers.) Fr. *H.S.*, virgineus (Wulf.) Fr. *H.*, subradiatus (Schum.) Fr. var. lacmus Fr. *H.*, laetus (Pers.) Fr. *H.*, puniceus Fr. *H.*, chlorophanus Fr. *H.*, coccineus (Schaeff.) Fr. *H.*, psittacinus (Schaeff.) Fr. *S.*

Lactarius torminosus (Schaeff.) Fr. *S.D.*, turpis (Weinm.) Fr. *S.*, deliciosus (L.) Fr. *S.*, quietus Fr. *S.P.*, rufus Fr. *H.*, glyciosmus Fr. *S.*, subdulcis (Bull.) Fr. *H.S.*

Russula nigricans (Bull.) Fr. *S.D.*, furcata (Pers.) Fr. *S.*, rosacea (Pers.) Fr. *S.*, drimeia Cke. *H.S.M.*, incarnata Quél. *S.*, virescens (Schaeff.) Fr. *S.P.*, atropurpurea (Krombh.) Maire *S.*, lepida Fr. *P.*, vesca Fr. *S.*, cyanoxantha (Schaeff.) Fr. *H.S.*, heterophylla Fr. *S.*, consobrina Fr. *S.*, fellea Fr. *H.S.*, emetica (Schaeff.) Fr. *S.*, ochroleuca (Pers.) Fr. *S.P.*, fragilis (Pers.) Fr. *H.S.*

Cantharellus cibarius Fr. *H.S.P.*

Marasmius oreades (Bolt.) Fr. *M.*

Androsaceus androsaceus (L.) Pat. *H.D.* rotula (Scop.) Pat. *D.*, Hudsonii (Pers.) Pat. *P.D.*

Panus torulosus (Pers.) Fr. *D.*, stypticus (Bull.) Fr. *P.*

Lenzites betulina (L.) Fr. *H.P.*

Pluteus cervinus (Schaeff.) Fr. *S.D.*

Entoloma jubatum Fr. *S.*, costatum Fr. *P.*, sericeum (Bull.) Fr. *H.D.*

Clitopilus prunulus (Scop.) Fr. *S.*

Leptonia lampropus Fr. *H.S.*, chloropolia Fr. *H.*, sericella (Fr.) Quél. *H.*

Nolanea pascua (Pers.) Fr. *H.*, proletaria Fr. *H.S.*, mammosa (L.) Fr. *P.*

Pholiota squarrosa (Mull.) Fr. *H.S.P.*

Inocybe rimosa (Bull.) Fr. *H.D.*, asterospora Quél. *S.D.*, eutheles B. and Br. *D.*, geophylla (Sow.) Fr. *H.P.D.*, maritima Fr. *H.*

Hebeloma fastibile Fr. *S.*, mesophaeum Fr. *P.*

Flammula carbonaria Fr. *H.*, sapinea Fr. *D.*

Naucoria escharoides Fr. *H.*

Galera tenera (Schaeff.) Fr. *S.*, hypnorum (Schrank) Fr. *H.M.*

Tubaria furfuracea (Pers.) W. G. Sm. *H.D.*

Cortinarius (Phlegmacium) triumphans Fr. *S.*, balteatus Fr. *H.*, varius (Schaeff.) Fr. *H.P.*,
(Myxacium) elatior Fr. *H.S.*, alboviolaceus (Pers.) Fr. *S.*,
(Dermocybe) tabularis (Bull.) Fr. *S.*, anomalus Fr. *S.*, miltinus Fr. *S.*, sanguineus (Wulf.) Fr. *H.P.*, cinnamomeus (L.) Fr. *H.P.* var. semisanguineus Fr. *H.*,
(Telamonia) hinnuleus (Sow.) Fr. *H.*, hemitrichus (Pers.) Fr. *H.*, rigidus (Scop.) Fr. *H.S.*, paleaceus (Weinm.) Fr. *H.*,
(Hydrocybe) leucopus (Pers.) Fr. *H.M.*, acutus (Pers.) *S.*

Paxillus involutus (Batsch) Fr. *H.S.*, panuoides Fr. *P.*

Psaliota arvensis (Schaeff.) Fr. *M.*, campestris (L.) Fr. *S.*, var. silvicola (Vitt.) Fr. *S.*

Stropharia aeruginosa (Curt.) Fr. *S.P.*, semiglobata (Batsch) Fr. *H.M.*, squamosa Fr. *H.*, merdaria Fr. *H.*, coronilla (Bull.) Fr. *D.*

Hypholoma capnoides Fr. *H.*, epixanthum (Paul.) Fr. *H.*, fasciculare (Huds.) Fr. *H.S.P.*, pyrotrichum (Holmsk.) Fr. *H.*, velutinum (Pers.) Fr. *P.*, appendiculatum (Bull.) Fr. *S.D.*, hydrophilum (Bull.) Fr. *H.P.*
Psilocybe semilanceata Fr. *H.M.*, foenisecii (Pers.) Fr. *S.*
Coprinus comatus Fl. Dan. *S.*, atramentarius (Bull.) Fr. *H.*, picaceus (Bull.) Fr. *H.*, flocculosus (DC.) Fr. *H.*, micaceus (Bull.) Fr. *S.*, radiatus (Bolt.) Pers. *M.*, plicatilis (Curt.) Fr. *S.*
Panaeolus campanulatus (L.) Fr. *H.*, papilionaceus (Bull.) Fr. *S.*
Anellaria separata (L.) Karst. *H.D.*
Psathyrella gracilis (Pers.) Fr. *S.D.*, atomata Fr. *S.*
Boletus luteus (L.) Fr. *H.P.*, elegans (Schum.) Fr. *H.S.P.*, granulatus (L.) Fr. *D.*, bovinus (L.) Fr. *H.*, badius Fr. *S.P.*, piperatus (Bull.) Fr. *S.*, variegatus (Swartz) Fr. *H.*, chrysenteron (Bull.) Fr. *H.S.D.*, subtomentosus (L.) Fr. *H.S.*, parasiticus (Bull.) Fr. *D.*, edulis (Bull.) Fr. *S.*, luridus (Schaeff.) Fr. *H.S.*, scaber (Bull.) Fr. *H.S.P.*
Fistulina hepatica (Huds.) Fr. *S.P.D.*
Polyporus squamosus (Huds.) Fr. *H.*, f. erecta Bres. *D.*, elegans (Bull.) Fr. var. nummularius Fr. *S.*, caesius (Schrad.) Fr. *S.P.*, rutilans (Pers.) Fr. *H.S.*, adustus (Willd.) Fr. *H.*, hispidus (Bull.) Fr. *S.*, dryadeus (Pers.) Fr. *S.*, betulinus (Bull.) Fr. *S.*
Fomes ulmarius (Sow.) Fr. *S.D.*, annosus Fr. *D.*, fomentarius (L.) Fr. *S.*, pomaceus (Pers.) Fr. *M.*
Ganoderma applanatum (Pers.) Pat.
Polystictus versicolor (L.) Fr. *H.S.P.D.*, radiatus (Sw.) Fr. *H.S.D.*, hirsutus (Schrad.) Fr. *H.S.P.*, zonatus (Nees.) Fr. *S.*, abietinus (Dicks.) Fr. *H.*
Poria terrestris (DC.) Fr. *H.*, sanguinolenta Fr. *S.D.*
Daedalea quercina (L.) Fr. *D.*
Merulius tremellosus (Schrad.) Fr. *H.*, corium (Pers.) Fr. *H.*, rufus (Pers.) Fr.
Hydnum repandum (L.) Fr. *P.*, auriscalpium (L.) Fr. *H.*
Irpex obliquus (Schrad.) Fr. *H.S.P.D.*
Radulum orbiculare Fr. *S.*
Phlebia merismoides Fr. *H.S.*
Grandinia granulosa Fr. *H.*, Brinkmanni Bres. (Corticioid form).
Odontia fimbriata (Pers.) Fr. *H.*, farinacea (Pers.) Quél. *H.*, bicolor (A. and S.) Bres. *H.*
Thelephora terrestris Ehrb. *S. H.*
Stereum hirsutum (Willd.) Fr. *H.S.D.*, sanguinolentum (A. and S.) Fr. *P.*, rugosum (Pers.) Fr. *H.S.D.*
Hymenochaete rubiginosa (Dicks.) Lév. *S.*, cinnamonea (Pers.) Bres. *P.*
Corticium lacteum Fr. *H.*, laeve (Pers.) Fr. *S.*, Sambuci (Pers.) Fr. *S.*, porosum Berk., praetermissum (Karst.) Bres. *P.*, albostramineum (Bres.) Wakef. *P.*, lactescens Berk. *H.*, lividum (Pers.) Fr.
Peniophora quercina (Pers.) Cke. *H.S.*, cinerea (Fr.) Cke. *S.*, velutina (DC.) Cke. *H.*, incarnata (Pers.) Cke., hydnoides Cke. and Mass., pubera (Fr.) Sacc.
Coniophora arida Fr. *P.*
Hypochnus isabellinus Fr. *H S.*, fuscus (Pers.) Karst., ferrugineus (Pers.) Fr., roseo-griseus Wakef. and Pears. var. lavendulaceus Pears. *P.*, granulosus (Peck) Burt *P.*
Exobasidium Vaccinii Woron. *H.P.*
Cyphella alboviolascens Karst. *H.P.*, capula (Holmsk.) Fr. *H.*
Clavaria cinerea (Bull.) Fr. *S.D.*, rugosa (Bull.) Fr. *H.S.D.*, stricta (Pers.) Fr. *S.*, fusiformis (Sow.) Fr. *S.P.D.*, luteoalba Rea *H.*, dissipabilis Britz. *H.*
Pistillaria micans (Pers.) Fr. *P.*, quisquiliaris Fr. *H.P.*, puberula Berk. *H.*
Hirneola Auricula-Judae (L.) Fr. on *Berberis arcuata S.*, on *Ilex D.*
Exidia glandulosa (Bull.) Fr. *D.*
Tremella mesenterica (Retz.) Fr. on *Ulex H.D.*
Femsjonia luteoalba Fr. *S.*
Dacryomyces deliquescens (Bull.) Duby *H.*
Calocera cornea (Batsch) Fr. *H.P.*
Phallus impudicus (L.) Pers. *H.*
Mutinus caninus (Huds.) Fr. *D.*
Cyathus striatus Hoffm. *S.*

Nidularia pisiformis Tul. *H.*
Geaster fimbriatus Fr. *P.*
Bovista plumbea Pers. *H.*, nigrescens Pers. *H.S.*
Lycoperdon perlatum Pers. *S.*, depressum Bon. *M.P.*, pyriforme (Schaeff.) Pers. *D.*
Scleroderma vulgare Horn. *H.S.D.*, verrucosum (Vaill.) Pers. *S.P.D.*

UREDINEAE.

Uromyces sparsus (K. et Sch.) Lév. on *Spergularia salina*, *P. Marsh*, Loti Blytt *M.*, striatus Schroet. on *Trifolium minus P.*, Trifolii (Hedw.) Lév. *P.*, flectens Lagerh. *M.*, Fabae (Pers.) de By. on Broad bean *M.S.*, on *Vicia sepium P.*, Valerianae (Schum.) Fuck. on *V. sambucifolia P.*, Salicorniae (DC.) de By. *P. Marsh*, Polygoni (Pers.) Fuck. *S.*, Rumicis (Schum.) Wint. *H.S.P.*, Dactylidis Oud. *H.S.P.*
Puccinia Violae (Schum.) DC. *H.S.P.D.*, Lychnidearum Link, *H.P.*, Malvacearum Mont. *M.D.*, pulverulenta Grev. *H.*, Circaeae Pers. *H.S.P.D.*, Aethusae Mart. *P.*, Absinthii DC. *P.*, on *Artemesia Absinthium*, obtegens (Link) Tul. *S.D.*, expansa Link. *P.*, Cirsii Lasch. *M.S.*, Hieracii (Schum.) Mart. *P.D.*, Hypochoeridis Oud. *D.*, Lapsanae (Schultz.) Fuck. *P.*, Taraxaci Plowr. *D.*, Primulae (DC.) Duby *H.S.P.D.*, Glechomatis DC. *H.*, Menthae Pers. on *Calamintha clinopodium H.*, and *Mentha aquatica P.*, annularis (Str.) Schlecht. *P.*, Acetosae (Schum.) Koern. *H.*, Iridis (DC.) Wallr. on *Iris foetidissima P.D.*, oblongata (Link.) Wint. *P.*, Caricis (Schum.) Rebent. *H.*, graminis Pers. *H.S.P.D.*, glumarum (Schm.) Erikss. and Henn. *P.*, dispersa Erikss. and Henn. *P.*, Baryi (B. and Br.) Wint. *H.S.P.*, Phragmitis (Schum.) Koern. *H.P.D.*, Poarum (Niels.) Wint. *P.*
Phragmidium subcorticium (Schrank) Wint. *P.*, violaceum (Schultz.) Wint. *H.S.P.D.*
Kuehneola (Phragmidium) albida (Kuehn.) Magn. *D.*
Coleosporium Euphrasiae (Schum.) Wint. *P.*, Melampyri (Rebent.) Kleb. *P.*, Senecionis (Pers.) Fr. *H.S.P.D.*, Sonchi-arvensis (Pers.) Lév. *P.*, Tussilaginis (Pers.) Kleb. *H.S.P.D.*
Pucciniastrum Circaeae (Schum.) Schroet. *D.*, Agrimoniae (DC.) Tranzsch. *P.*
Melampsora Hypericorum (DC.) Schroet. on *Hypericum Androsaemum*, Laricicaprearum (Link) Karst. *H.S.P.*
Melampsoridium betulinum (Pers.) Kleb. *H.S.P.D.*
Thecopsora (Pucciniastrum) Vacciniorum (Link) Karst. *H.P.*, Dieteliana (Syd.) Magn. on *Polypodium vulgare D.*
Milesina (Melampsorella) Blechni (Syd.) Magn. *D.*
Uredo Scolopendri (Schroet.) *P.D.*

USTILAGINEAE.

Spacelotheca Hydropiperis (Schum.) de By. *H.P.*

PYRENOMYCETES.

Sphaerotheca pannosa (Wallr.) Lév. *M.*, Castagnei Lév. *S.P.*
Podosphaera oxyacantha (DC.) de By. *H.*, myrtillina (Schub.) Kunze. *H.P.*, leucotricha Salm. *H.*
Uncinula Aceris (DC.) Sacc. *H.S.P.D.*
Microsphaera Grossulariae (Wallr.) Lév. *D.*, mougeotii Lév. on *Lycium M.D.*
Phyllactinea suffulta (Rebent.) Sacc. *P.*
Erysiphe Cichoracearum DC. *H.P.*, graminis DC. *D.*, Polygoni DC. *H.D.*
Eurotium herbariorum (Wigg.) Link *P.*,
Nectria cinnabarina (Tode) Fr. *S.P.*, Peziza (Tode) Fr. *D.*
Hypomyces rosellus (A. and S.) Tul. *H.*, aurantius (Pers.) Tul. *H.*
Hypocrea rufa (Pers.) Fr. *H.*, fungicola Karst. *S.*
Claviceps purpurea (Fr.) Tul. *S.P.D.*, microcephala (Wallr.) Wint. *H.P.*
Cordyceps militaris (L.) Link *S.*, ophioglossoides (Ehrb.) Link *H.P.*
Chaetomium elatum Kunze. *P.*
Sordaria macrospora Auersw. *H.*, fimicola (Rob.) Ces. and de Not. *H.*, discospora (Auersw.) Niessl. var. major Wint. *H.*, maxima Niessl. *H.*

Podospora coprophila (Fr.) Ces. and de Not. *D.*
Delitschia minuta Fuck. *H.*
Sporormia ambigua Niessl. *H.*
Trichosphaeria pilosa (Pers.) Fuck. *S.*
Herpotrichia Pinetorum (Fuck.) Wint. *H.* on *Ulex.*
Leptospora ovina (Pers.) Fuck. *D.*
Chaetosphaeria phaeostroma (Dur. and Mont.) Wint. *S.*
Rosellinia mammiformis (Pers.) Wint. *S.*
Melanomma Pulvis-pyrius (Pers.) Fuck. *H.*, fuscidulum Sacc. *P.* on *Sambucus*
Zignoëlla ovoidea (Fr.) Sacc. *H.*, ostioloidea (Cke.) *P.*
Ceratostomella cirrhosa (Pers.) Sacc. *H.*
Stigmatea Robertiani Fr. *P.*
Sphaerella punctiformis Sacc. *H.P.*
Venturia Rumicis (Desm.) Wint. *P.*, maculaeformis (Desm.) Wint. *H.*
Pleospora herbarum (Pers.) Rabh. *P.*
Anthostomella appendiculosa (B. and Br.) Sacc. *S.* on *Fraxinus.*
Diaporthe crustosa Sacc. and Roum. *H.*, decorticans (Lib.) Sacc. and Roum. *D* on *Prunus cerasus.*
Valsa Eutypa (Achar.) Nits. *M.H.* on *Fraxinus.*
Melanconis stilbostoma (Fr.) Tul. *H.S.*
Valsaria insitiva Ces. and de Not. *D.*
Diatrypella quercina (Pers.) Nits. *S.*
Diatrype stigma (Hoffm.) de Not. *H.*, disciformis (Hoffm.) Fr. *P.*
Hypoxylon multiforme Fr. *S.H.*, coccineum Bull. *S.P.M.*
Daldinia concentrica (Bolt.) Ces. and de Not. *H.*
Ustulina vulgaris Tul. *H.*
Xylaria Hypoxylon (L.) Grev. *H.S.P.D.*, polymorpha (Pers.) Grev. *D.*
Phyllachora graminis (Pers.) Fuck. *P.*, Junci (Fr.) Fuck. *H.*
Dothidella Ulmi (Duv.) Wint. *H.*

HYSTERIACEAE.

Hypoderma Rubi (Pers.) Schroet. *H.*
Lophodermium cladophilum (Lév.) Rehm. *H.*
Lophium mytillinum (Pers.) Fr. *H.*
Hysterographium Fraxini (Pers.) de Not. *S.*

MYRIANGIACEAE.

Myriangium Duriaei Mont. and Berk. (in sensu lato) *H.*

TUBERACEAE.

Elaphomyces granulatus Fr. *H.S.P.*, variegatus Vitt. *P.*

DISCOMYCETES.

Galactinia succosa (Berk.) Sacc. *P.*
Pachyella depressa (Phill.) Boud. (? Humaria oocardii (Kalch.) Sacc.) *H.P.*
Peziza aurantia Pers. *H.*
Lachea erinacea (Schwein.) Sacc. *P.*
Ciliaria scutellata (L.) Quél. *S.*, setosa (Nees) Boud. *H.*
Cheilymenia stercorea (Pers.) Boud. *D.*, coprinaria (Cooke) Boud. *M.*
Coprobia granulata (Bull.) Boud. *D.*
Ascobolus furfuraceus Pers. *D.*, vinosus Berk. *P.D.*, viridulus Phill. and Plowr. *P.*, glaber Pers. *D.*
Dasyobolus immersus (Pers.) Sacc. *D.*
Saccobolus violascens Boud. *D.*
Ascophanus carneus (Pers.) Boud. *H.*, cervarius (Phill.) Boud. *H.*
Lasiobolus equinus (Mull.) Karst. *H.*, macrotrichus Rea *H.*
Rhyparobius crustaceus (Fuck.) Rehm. *D.*, myriosporus (Cr.) Boud. *H.*
Ascozonus argenteus (B. and Br.) Boud. *H.*
Geoglossum ophioglossoides (L.) Sacc. *P.*
Leotia lubrica (Scop.) Pers. *P.*

Cudoniella acicularis (Bull.) Schroet. *P.*
Ombrophila clavus (A. et S.) Cke. *H.*, alniella (Nyl.) Karst. *P.*
Calycella citrina (Hedw.) Quél. *H.*, claroflava (Grev.) Boud. *H*, ferruginea (Schum.) Boud. *H.*
Coryne sarcoides (Jacq.) Tul. *H.S.P.D.*
Bulgaria inquinans (Pers.) Fr. *H.S.D.*
Polydesmia pruinosa (B. and Br.) Boud. *H.P.*
Orbilia vinosa (A. and S.) Karst. *H.*, coccinella (Somm.) Fr. *P.*, leucostigma Fr. *H.S.P.*, xanthostigma Fr. *P.D.*
Sclerotinia Curreyana (Berk.) Karst.—sclerotia (Sclerotium roseum Moug.) only *S.*
Phialea firma Pers. *H.S.P.*
Chlorosplenium aeruginosum (Oeder.) de Not. *D.*, versiforme (Pers.) de Not. *H.*
Helotium herbarum (Pers.) Fr. *S.D.*, phyllophilum (Desm.) Karst. *D.*, fructigenum (Bull.) Fuck. *S.*, virgultorum (Wahl.) Karst. *H.*, melleum B. and Br. *H.*, moniliferum (Fuck.) Rehm. *D.*
Belonidium vexatum de Not. *H.*
Dasycypha virginea (Batsch) Fr. *H.*, nivea (Hedw. f.) Sacc. *D.*, scintillans Mass. *D.*, ciliaris (Schrad.) Sacc. *D.*, diplocarpa Curr. *H.*
Erinella juncicola (Fuck.) Sacc. *S.*
Lachnella corticalis (Pers.) Fr. *D.*, prasina Quél. *H.*
Trichoscypha calycina (Schum.) Boud. *H.P.*
Hyaloscypha punctiformis (Grev.) Boud. *D.*, dentata (Pers.) Boud. *D.*
Mollisia fallax (Desm.) Gill. *D.*, aquosa (B. and Br.) Phill. *D.*, discolor (Mont. and Fr.) Phill. *P.*, cinerea (Batsch) Karst. *H.S.P.*, ventosa Karst. *D.*
Pseudopeziza Trifolii (Biv.-Bern.) Fuck. *M.*
Stegia Ilicis Fr. *H.S.P.D.*
Rhytisma acerinum (Pers.) Fr. *S.D.*, punctatum (Pers.) Fr. *D.*

PHYCOMYCETES.

Cystopus candidus (Pers.) de By. *S.*
Plasmopara nivea (Ung.) Schroet. *P.*
Bremia Lactucae Regel. *M.*
Peronospora Myosotidis de By. *P.*, Viciae (Berk.) de By. *P.*, Trifoliorum de By. *M.*, Urticae (Lib.) de By. *D.*, parasitica (Pers.) Tul. *S.*, alta Fuck. *H.S.P.D.*
Mucor racemosus Fres. *S.*
Phycomyces nitens (Agardh.) Kunze *P.*
Spinellus fusiger (Link) van Tiegh. *H.S.*
Syzygites megalocarpus Ehrb. *H.*
Pilaira anomala (Ces.) Schroet. *D.*
Pilobolus crystallinus (Wigg.) Tode *D.*, longipes van Teigh. *S.*
Piptocephalis Freseniana de By. *S.*
Protomyces macrosporus Ung. on *Aegopodium Podagraria M.*

SPHAEROPSIDEAE.

Phyllosticta Berberidis Rabh. *D.*, maculiformis Sacc. *P.D.*, Bolleana Sacc. *M.*, fraxinicola Curr. *H.*, Mahoniae Sacc. and Speg. *D.*, leptidea (Fr.) Allesch. *H.*, Brassicae (Curr.) Westend. *S.*
Phoma conigena Karst. *H.P.*, strobiligena Desm. *H.*, samararum Desm. *H.*
Cytospora Lauro-cerasi Fuck. *D.*
Actinonema Rosae (Lib.) Fr. *M.S*
Septoria graminum Desm. *M.*, Hederae Desm. *H.D.*, Rubi Westend. *H.S.P.*, thecicola B. and Br. on *Polytrichum* capsules *H.*, Violae Westend. *H.*

HYPHOMYCETES.

Oidium erysiphoides Fr. *H.S.P.D.*, alphitoides Griff. and Maub. *H.S.P.D.* on *Fagus D.*, Euonymi-Japonicae Salm. *M.*
Botryosporium pulchrum Corda *D.*
Rhinotrichum Thwaitesii B. and Br. *S.*
Sepedonium chrysospermum (Bull.) Fr. *H.S.P.D.*

Ovularia obliqua (Cooke) Oud. *H.S.P.D.*, primulana Karst. *H.*
Meria Laricis Vuill. *H.*
Botrytis cinerea Pers. *H.S.*
Verticillium agaricinum (Link.) Corda *S.*, epimyces B. and Br. *S.*
Trichothecium roseum Link *P.*
Arthrobotrys superba Corda *D.*
Ramularia Urticae Ces. *S.D.*, acris Lindr. *D.*, lactea (Desm.) Sacc. *H.S.*, Primulae v. Thum. *H.S.*, calcea (Desm.) Ces. *H.S.D.*, plantaginea Sacc. and Berl. *S.D.*, sambucina Sacc. *H.*, Cirsii Allesch. *P.*, Hypochoeridis Mag. *P.*, Taraxaci Karst. *M.*
Cladosporium herbarum (Pers.) Link. *H.S.*, epiphyllum (Pers.) Mart. *H.D.*
Cercospora Mercurialis Passer. *H.*
Bispora monilioides Corda *D.*
Stilbella erythrocephala (Ditm.) Lind. *D.*, fimetaria (Pers.) Lind. *D*
Tilachlidium tomentosum (Schrad.) Lind. *H.*
Isaria farinosa (Dicks.) Fr. *H.S.P.*
Aegerita candida Pers. *H.*

MYCETOZOA FOUND DURING THE MINEHEAD FORAY.

By G. Lister, F.L.S.

The visit of the British Mycological Society to Minehead was arranged to extend from Monday, September 27th to Saturday, October 2nd; several of our members however arrived a few days earlier and remained a few days later than the appointed time. In hunting for Mycetozoa a good average result was obtained.

The weather had been on the whole fine and dry for some weeks previously, and this perhaps accounted for an even richer harvest not having been made. The sheltered woods lying among the folds of Exmoor and the hills of the coast are known to be favourable to Mycetozoa from the researches of Mr N. G. Hadden, who resides in the district, and who, in the past few years, has found there over a hundred species. Thanks to his guidance we were conducted to good hunting grounds.

On Tuesday, September 28th, we visited Horner Woods, below Dunkerry Beacon; these consisted chiefly of oak, ash and holly with undergrowth of bracken, bramble and moist grass in the valleys, and heather on higher ground. Among the more interesting specimens obtained was *Didymium dubium*, and a large but weathered growth of *Physarum leucopus*, both on dead holly leaves. *Fuligo muscorum* was found on heather in two places, in the apricot plasmodium stage; on being brought

indoors it soon developed into the characteristic small compact aethalia. A fresh growth of shining black sporangia of *Hemitrichia Vesparium* was obtained on the same dead tree where it had been found more or less abundantly for the last four years. *Hemitrichia clavata* has occurred also on this tree, but was not in evidence on the present occasion.

On Wednesday, September 29th, the party drove to Selworthy. Here extensive woods of oak, holm oak, and ash, with some conifers, clothe the south side of the coast hills; in many parts there is undergrowth of Rhododendron and bramble. Large developments of *Physarum bitectum* were found within bramble thickets, together with a curious form of *Diderma effusum* with small depressed pale brown and much wrinkled sporangia. *Dictydium cancellatum* and *Licea flexuosa* were obtained on coniferous wood.

Thursday, September 30th, when the fine woods above Porlock were visited, was wet. The trees consisted of oak, ash, holly, walnut, and some Scots pine and larch; with undergrowth of fern, grass and, on higher ground, heather. On the surface of a large sawdust heap a quantity of the white plasmodium of *Arcyria denudata* was emerging. A handsome growth of *Trichia Botrytis* forma *cerifera* was found on a log half submerged in water. When still moist, the black sporangia were seen to be distinctly mottled with translucent yellow patches, so that at a glance it was referred to this variety. When dry, however, only about half a dozen sporangia exhibit the bright yellow warts of wax characteristic of the variety; the remaining sporangia are either purple-black veined with glossy red-brown lines of dehiscence, or opaque purple-black mottled with glossy yellowish areas, due probably to thin deposits of wax. An interesting feature of these black sporangia is that their dark colour is in part caused by dense deposits of dark plasmodic granules each about 1 μ diam., lying between the two layers of the sporangium-wall; such granules have been usually considered to occur only in sporangia of the Order *Heterodermaceae*, including the genera *Cribraria*, *Dictydium* and *Lindbladia*; they have not been seen in the brown or rosy forms of *Trichia Botrytis*, nor are they present in black sporangia of *Trichia floriformis*.

On Friday, October 1st, the grounds of Dunster Castle were visited. In a wood-yard *Perichaena depressa*, found on elm logs, proved to be a new record for Somerset; the beds of old sawdust were teeming with plasmodium of *Fuligo septica*.

Saturday, October 3rd. Some of our party again went to the Horner Woods and Porlock, where among other species *Stemonitis splendens* var. *flaccida* and a single sporangium of *Colloderma oculatum* were found.

Two days before we assembled Mr Hadden had obtained *Lamproderma arcyrionema* and *Trichia favoginea* in Porlock Woods, and soon after we left he found there *Enteridium olivaceum, Stemonitis hyperopta, Cribraria pyriformis* and *Arcyria Oerstedtii,* all new to the district, the three last species were on sawdust heaps. *Cribraria pyriformis* is rare in England, having only been met with once before in its typical form; Dr W. T. Elliott obtained it in the New Forest near Lyndhurst in December 1916. The var. *notabilis* has been found several times in Ashdown Forest, Sussex, on sawdust heaps, by Mr W. E. Nicholson. In Scotland *C. pyriformis* has been obtained repeatedly.

In the following list *H.* refers to Horner Woods; *S.* to Selworthy; *P.* to Porlock Woods and *D.* to Dunster.

Ceratiomyxa fruticulosa (Müll.) Macbr. *H.S.*
Badhamia utricularis (Bull.) Berk. *H.D.*
B. panicea (Fries) Rost. *D.*
Physarum leucopus Link *H.*
P. nutans Pers. *H.S.P.D.*
P. viride (Bull.) Pers. *P.D.*
P. bitectum Lister *H.S.*
Fuligo septica (L.) Gmel. *H.P.D.*
F. muscorum Alb. and Schw. *H.*
Craterium minutum (Leers) Fries *H.S.P.D.*
Leocarpus fragilis (Dicks.) Rost. *H.D.*
Diderma deplanatum Fries *H.D.*
D. effusum (Schw.) Morg. *H.S.*
Didymium difforme (Pers.) Link *S.P.*
D. dubium Rost. *H.P.*
D. squamulosum (Alb. and Schw.) Fries *H.S.P.D.*
D. nigripes Fries *S.D.*
D. nigripes var. xanthopus Lister *H.S.*
Colloderma oculatum (Lipp.) G. Lister *P.*
Stemonitis fusca Roth. *H.S.P.*
S. splendens Rost. var. flaccida Lister *P.*
Stemonitis hyperopta Meylan (Syn. Comatricha typhoides var. heterospora Rex.) *P.*
Lamproderma scintillans (Berk. and Br.) Morg. *P.*
L. arcyrionema Rost. *P.*
Comatricha nigra (Pers.) Schroet. *H.S.*
Cribraria argillacea Pers. *S.D.*
C. rufa (Roth.) Rost. *P.*
C. vulgaris Schrad. *D.P.*
C. pyriformis Schrad. *P.*
Dictydium cancellatum (Batsch) Macbr. *S.P.*
Licea flexuosa Pers. *H.S.P.*
Tubifera ferruginosa Gmel. *S.*
Enteridium olivaceum Ehrenb. *P.*
Reticularia Lycoperdon Bull. *H.S.*
Lycogala epidendrum (L.) Fries *H.P.*
Trichia favoginea Pers. *P.*
T. affinis de Bary *H.S.P.*
T. persimilis Karst. *H.S.D.*
T. varia Pers. *H.S.P.D.*
T. Botrytis Pers. *H.P.* forma cerifera Lister *P.*
T. decipiens (Pers.) Macbr. *S*
Hemitrichia Vesparium (Batsch) Macbr. *H.*
Arcyria denudata (L.) Wettst. *H.S.*
A. incarnata Pers. *H.S.*
A cinerea (Bull.) Pers. *H.P.*
A. nutans (Bull.) Grev. *H.*
A. Oerstedtii Rost. *P.*
Perichaena depressa Lib. *D.*
P. corticalis (Batsch) Fr. *H.*

This list of 49 species is the third largest that has been obtained on one of our forays; the two larger being those from Forres (81) and from Selby (51).

MYCETOZOA AT PORLOCK IN OCTOBER 1920.

By Norman G. Hadden.

A dry September with frequent cold winds had rendered the local woods much too dry for an abundant growth of Mycetozoa at the time of the British Mycological Society's Foray at Minehead, so that the wealth of species known to occur was but poorly represented. The very heavy rains which fell during the first week of October, followed by warm dull days with thick mists in the early morning provided ideal conditions for the development of sporangia of Mycetozoa. Two and three-year old heaps of coniferous sawdust which had been under observation all the summer and had yielded no specimens, quickly became the centre of interest and were bespangled with large masses of maturing plasmodium. The crimson and grey sporangia of *Arcyria denudata* and *A. cinerea* appeared in great abundance and were soon accompanied by a large semi-circular patch of white plasmodium which proved to be the very beautiful *Arcyria Oerstedtii*. All of this development which remained exposed on the sawdust was completely destroyed by a heavy rain storm; fortunately I had brought a quantity of it in-doors where the formation of the sporangia and change from white to ochraceous brown and finally to rich crimson was extremely interesting to observe. Sawdust developments are more at the mercy of the elements and become mouldy sooner than the ordinary growths matured on dead logs or fallen branches which afford them a certain amount of protection, but on the other hand the growths on sawdust are usually larger and more luxuriant. Two small developments of the lilac-brown *Stemonitis hyperopta* was a somewhat unexpected find on the sawdust. Another sawdust heap situated about 900 ft. above sea level proved of great interest; large masses of the little nut-brown *Cribraria aurantiaca* carpeted its surface intermingled with *Dictydium cancellatum* in smaller quantity. The green strands of plasmodium of the Cribraria were very conspicuous as they crept over the sawdust when about to mature. Chips of larch wood lying on the heap provided a home for quantities of the black *Licea flexuosa*, the dark olive-green aethalia of *Enteridium olivaceum* and a fine growth of the rare and handsome *Cribraria pyriformis* which appears to be particularly partial to these old heaps of coniferous sawdust. Heavy rain again fell in the middle of the month succeeded by somewhat cold and dull weather; from this time all sawdust developments ceased to appear but logs, dead gorse twigs, hedge

clippings etc. began to bear a rich harvest of Mycetozoa of many species. *Physarum pusillum* and *Comatricha tenerrima* appeared together in some quantity on decaying stems of *Oenanthe crocata* in a very wet copse. *Didymium Clavus* studded old gorse twigs with hundreds of grey nail-like sporangia, even exceeding the goblets of *Craterium minutum* in their profusion.

The bare and wind-swept valley known as Smallacombe has proved to be the habitat of a number of interesting species; its steep sides have been denuded of all trees for several years and the only shelter is afforded by heather, mountain fern and small whortleberry bushes. The lowest slope is always moist and covered with a rich growth of mosses down to the path-side, amongst which nestle the dainty ivy-leafed Campanula, bog pimpernel and Cornish moneywort. Facing north-west, it is a cold and draughty combe even in summer since the winds either sweep up it from the sea or blow down it directly from the Exmoor plateau. On October 23rd I noticed a fine development of the sessile sporangia of *Diderma ochraceum* on wet moss at the foot of the combe and a hurried search soon revealed many more large growths of this very uncommon species, sometimes sheltering under heather but more often fully exposed on the moss. Fresh developments were in all stages of growth from the lemon-yellow plasmodium to ochraceous ripe sporangia; the following week they were still appearing but now accompanied by masses of orange plasmodium developing into the inconspicuous though sturdy sporangia of *Lepidoderma tigrinum*. As these two species have frequently been found in association (possibly there may be some connection between them not as yet understood) it was particularly interesting to be able to study their growth side by side; the lemon plasmodium always produced the sessile ochraceous sporangia and the orange plasmodium as constantly developed into stout stalked deep olive sporangia with the characteristic white crystalline discs. Although the moss was teeming with plasmodia I never found the lemon and orange veins touch one another or mature upon the same stem. Associated with the Diderma and Lepidoderma were a number of small short-stalked sporangia of *Lamproderma columbinum* very closely resembling *L. violaceum* in habit and quite different in appearance to the handsome long-stalked large sporangia of typical *L. columbinum* which had appeared in a three-inch wide mass on short moss near by. This is the usual form in the Porlock district and is not infrequent in winter on bare soil by wet woodland tracks. It is interesting to note that whereas *Lepidoderma tigrinum* is usually only found on wet moss or very rotten wood I have recently seen it in fine condition on Polytrichum growing on a stony slope in CulboneWood

where this moss and *Sedum anglicum* were almost the only plants which had succeeded in obtaining a roothold amongst the scree. Some rotten pine and larch logs lying on the hillside above Smallacombe were covered with rich growths of *Colloderma oculatum, Enerthenema papillatum, Comatricha elegans, Stemonitis ferruginea, S. herbatica* (with very lax capillitium), *Licea flexuosa* and a small development of *Dianema corticatum*, a species which does not appear to have been obtained in southern England previously. It so closely resembles *Licea flexuosa* in the field that it is easily overlooked, but the pinkish colour of the spores in mass (instead of olive) is a help in recognising it. On very wet moss by a spring side *Fuligo muscorum* appeared, one inconspicuous ripe aethalium along with the more showy apricot plasmodium which matured in-doors after a couple of days. On an old ash tree growing near the mouth of the combe I detected several of the tiny grey hemispherical sporangia of *Badhamia affinis* perched among tufts of Orthotrichum and Frullania some five feet from the ground. As each sporangium grows by itself it is by no means conspicuous, but though only recorded in Britain from Aberdeenshire and Cornwall it is quite likely to be found anywhere when carefully searched for, nearly all the arboreal Mycetozoa being inconspicuous but evidently of wide distribution. Similarly it is not likely that Japan, West Somerset and Aberdeenshire are the only localities for the typical *Hemitrichia minor*! It seems impossible to lay down any rules as to searching for the arboreal species; most of Mr Cran's wonderful Scottish finds have been upon exposed trunks sparsely clad with lichen and moss, here my only success has been on ash trees in damp sheltered woods where mosses and lichens luxuriate on the bark. On the same tree which yielded *B. affinis* I collected some freshly emerged lemon-yellow sessile sporangia growing on moss low down on the trunk; by the time I reached home these sporangia had turned a dull green, the next morning they were a bright grass green; they finally matured into the yellow plasmodiocarps of the rare *Badhamia nitens* var. *reticulata*.

While gathering these interesting Mycetozoa it was a never-failing source of pleasure to listen to the belling of red deer stags, eager for a battle with a rival from some distant combe, to the hoarse croaking of ravens and the wild mewing cries of buzzards as they soared high overhead.

Since the above was written I have had the pleasure of finding about thirty sporangia of the remarkable *Diachaea cerifera* G. Lister (see Journal of Botany, vol. LI, Jan. 1913). The white plasmodium and newly developed sporangia occurred on the Hepatic *Pellia epiphylla* on a steep bank close to a small stream

in the wood above Porlock Weir. The dark purplish-brown iridescent sporangia are seated on stout yellowish stalks and are very similar in appearance to the specimens obtained by M. Meylan in the Jura Mountains. This is the first British record of *D. cerifera*; it has hitherto only been found in Norway, Switzerland and Japan.

THE LICHENS OF MINEHEAD DISTRICT.

By H. H. Knight, M.A.

For the first time since the Mycological Society has included Lichens in its program the autumn foray was held in a district where these plants were plentiful. A further interest in Lichens was given by Mr Paulson's excellent account of "The Sporulating Gonidia of *Evernia prunastri*."

Horner Wood was particularly rich in arboreal species. This is an old wood, and not like a modern plantation where the trees are too closely packed to admit light for Lichens growing on their trunks. The well known *Lobaria pulmonaria* was abundant, also *Nephromium lusitanicum* and three species of *Sticta*. Other conspicuous plants were *Synechoblastus nigrescens*, *Leptogium Burgessii*, and species of *Pannaria* and *Parmeliella*. *Thelotrema lepadinum* was plentiful on many of the hollies.

The woods at Selworthy and Porlock were less prolific, and more attention was given to the saxicolous species, which were found wherever rocks were exposed. In the wood at Dunster *Thelotrema* was again found on hollies; here too were *Enterographa crassa* and *Phaeographis dendritica* which were not seen at Horner.

At Minehead the shingle above high tide level, and rocks on the North Hill including Greenaleigh Point were examined. The rocks in the district were mostly Devonian sandstone, the calcareous species in the list being found on mortared walls.

For assistance in naming the Lichens in this list I am indebted to Dr Watson of Taunton and to Mr Paulson.

M. = Minehead. *H.* = Horner. *S.* = Selworthy. *P.* = Porlock. *D.* = Dunster. *f.* = fertile.

Calicium hyperellum Ach. *f.*, *H.*
Placynthium nigrum S. F. Gray *f.*, *M.H.D.*
Collema pulposum Ach. *f.*, *M.D.*
C. cheileum Ach. *f.*, *D.*
Synechoblastus nigrescens Anzi *H.*
S. rupestris A. L. Sm. *H.*
Leptogium lacerum S. F. Gray *f.*, *M.*; f. fimbriatum Nyl. *f.*, *H.*
L. Burgessii Mont. *f.*, *H.*

Parmeliella corallinoides A. Zahlbr. *f.*, *H.*
P. plumbea Wain. *f.*, *H.*
Pannaria rubiginosa Del. var. conoplea Koerb. *H.*
P. nebulosa Nyl. *f.*, *H.*
Peltigera canina Willd. *f.*, *H.*
P. rufescens Hoffm. *H.*; var. praetextata Nyl. *H.*
P. horizontalis Hoffm. *f.*, *M.*
Nephromium lusitanicum Nyl. *f.*, *H.*
Sticta fuliginosa Ach. *H.*
S. sylvatica Ach. *H.*
S. limbata Ach. *H.*
Lobaria pulmonaria Hoffm. *H.*
Parmelia physodes Ach. common.
P. perlata Ach. *P.D.*
P. caperata Ach. *H.D.*
P. saxatilis Ach. *M.S.*; f. furfuracea Schaer. *S.*
P. sulcata Tayl. *P.D.*
P. dubia Schaer. *H.D.*
P. revoluta Floerke *H.P.*
P. conspersa Ach. *M.*
P. fuliginosa Nyl. *M.S.*; var. laetevirens Nyl. *P.D.*
Evernia prunastri Ach. common.
Ramalina fastigiata Ach. *f.*, *M.D.*
R. farinacea Ach. *S.P.*
R. siliquosa A. L. Sm. *M.*
Usnea florida Web. *f.*, *H.*; var. hirta Ach. *H.*
Xanthoria parietina Th. Fr. *f.*, common; var. ectanea Oliv. *M.*
Placodium callopismum Mér. *f.*, *D.*
P. murorum DC. *f.*, *M.P.D.*
P. lobulatum A. L. Sm. *f.*, *M.*
P. citrinum Hepp. *f.*, *M.H.P.*
P. rupestre Branth and Rostr. *f.*, *D.*
Physcia pulverulenta Nyl. *f.*, *D.*
P. stellaris Nyl. var. cercidia Th. Fr. *f.*, *M.D.*
P. hispida Tuckerm. *D.*
P. orbicularis var. virella Dalla Torre and Sarnth. *M.*
Rinodina demissa Arn. *f.*, *M.S.*
Lecanora subfusca Ach. var. chlarona Ach. *f.*, *H.S.D.*; var. allophana Ach. *f.*, *H.*
L. rugosa Nyl. *f.*, *H.*
L. campestris B. de Lesd. *f.*, *H.D.*
L. coilocarpa Nyl. *f.*, *M.S.D.*
L. atra Ach. *f.*, common.
L. umbrina Massal. *f.*, *M.*
L. pallida Schaer. *f.*, *M.S.*
L. sordida Th. Fr. *f.*, *S.*
L. galactina Ach. *f.*, *M.D.*
L. conizaea Nyl. *f.*, *M.*
L. symmicta Ach. *f.*, *H.S.P.*
L. polytropa Schaer. *f.*, *M.S.*
L. parella Ach. *f.*, common.
L. cinerea Sommerf. *f.*, *M.*
L. calcarea Sommerf. *f.*, *D.*
Acarospora fuscata Th. Fr. *f.*, *S.*
A. smaragdula Massal. f. rufescens (Turn.) *f.*, *S.*
Lecania erysibe Mudd. *f.*, *M.*
Pertusaria faginea Leight. *H.S.D.*
P. lactea Nyl. *M.S.*
P. pertusa Dalla Torre and Sarnth. *f.*, *H.D.*
P. ceuthocarpa Turn. f. microstictica Cromb. *S.*
P. dealbata Cromb. *H.S.*
P. leioplaca Schaer. *f.*, *H.P.D.*
P. Wulfenii DC. *f.*, *H.P.*
Thelotrema lepadinum Ach. *f.*, *H.D.*
Phlyctis agelaea Koerb. *D.*
Baeomyces rufus DC. *f.*, *M.P.*
Cladonia sylvatica Hoffm. *H.S.*
C. foliacea Willd. *S.*
C. pyxidata Hoffm. *H.*
C. fimbriata Fr. *M.P.*; f. prolifera Retz. *P.*; var. simplex Wain. *D.*
C. pityrea Fr. *S.*
C. furcata Schrad. *S.*
C. flabelliformis Wain. *P.*; var. polydactyla Wain. *P.*
C. macilenta Hoffm. *D.*
C. Floerkeana Fr. *S.P.*
Lecidea quernea Ach. *f.*, *S.*
L. coarctata Nyl. *f.*, *S.*; var. elacista Cromb. *f.*, *S.*
L. uliginosa Ach. *f.*, *S.*
L. fuliginea Ach. *f.*, *D.*
L. protrusa Fr. *M.*
L. parasema Ach. *f.*, common; var. elaeochroma Ach. *f.*, *H.D.*
L. latypea Ach. *f.*, *S.*
L. contigua Fr. *f.*, common.
L. crustulata Koerb. *f.*, *M.H.*
L. sorediza Nyl. *P.*
L. rivulosa Ach. *f.*, *M.S.*
L. sylvicola Flot. var. infidula Cromb. *f.*, *H.S.*
Biatorella pruinosa Mudd f. nuda A. L. Sm. *f.*, *D.*
Biatorina littorella A. L. Sm. *f.*, *M.*
B. pilularis Koerb. *f.*, *H.*
B. atropurpurea Massal. *f.*, *H.*
B. lenticularis Koerb. *f.*, *M.P.*
Bilimbia aromatica Jatta, *f.*, *M.D.*
B. sabuletorum Branth and Rostr. *f.*, *M.*
Bacidia umbrina Branth and Rostr. *f.*, *P.*
Buellia canescens De Not. *M.P.D.*
B. spuria Koerb. *f.*, *S.*
B. myriocarpa Mudd, *f.*, *D.*
B. subdisciformis Jatta, *f.*, *M.*
B. coniops Th. Fr. *f.*, *M.*
B. confervoides Kremp. *f.*, *M.*
Rhizocarpum alboatrum Th. Fr. var. epipolia A. L. Sm. *f.*, *P.*

R. geographicum DC. *f.*, *M.S.*
R. viridiatrum Koerb. *f.*, *M.S.*
R. petraeum Massal. *f.*, *M.*
R. confervoides DC. *f.*, *M.S.P.*
Lecanactis premnea Weddell *f.*, *H.*
L. abietina Koerb. *f.*, *H.*
Arthonia lurida Ach. *f.*, *S.D.*
A. gregaria Koerb. *f.*, *H.*
A. radiata Ach. *f.*, *H.*; var. Swartziana Sydow, *f.*, *H.*
Lithographa dendrographa Nyl. *f.*, *H.*
Opegrapha atra Pers. *f.*, common; var. denigrata Schaer. *f.*, *S.*
O. varia Pers. *f.*, *P.*
O. vulgata Ach. *f.*, *H.D.*; var. siderella Nyl. *f.*, *H.*
Graphis elegans Ach. *f.*, *P.D.*; f. coacervata Leight. *f.*, *H.*
G. scripta Ach. *f.*, *H.*
Phaeographis inusta Muell.-Arg. *f.*, *H.*
P. dendritica Muell.-Arg. *f.*, *D.*
Enterographa crassa Fée *f.*, *D.*
Dermatocarpum aquaticum A. Zahlbr. *f.*, *H.S.*
Verrucaria maura Wahlenb. *f.*, *M.*
V. aquatilis Mudd *f.*, *D.*
V. margacea Wahlenb. *f.*, *P.*
V. submersa Schaer. *f.*, *H.P.*
V. viridula Ach. *f.*, *P.D.*
V. nigrescens Pers. *f.*, *H.*
V. glaucina Ach. *f.*, *M.*
V. maculiformis Krempelh. *f.*, *M.*
V. muralis Ach. *f.*, *P.*
Thelidium Nylanderi Krempelh. *f.*, *P.*
Acrocordia gemmata Koerb. *f.*, *H.P.*
A. biformis Oliv. *f.*, *H.S.*
A. epipolaea A. L. Sm. *f.*, *P.*
Arthopyrenia epidermidis Mudd *f.*, *H.P.*
A. punctiformis Arn. *f.*, *M.*
A. fallax Arn. *f.*, *H.P.*
Porina carpinea A. Zahlbr. *f.*, *P.*
Pyrenula nitida Ach. *f.*, *H.S.D.*

The following Fungus parasites were found on Lichens:

Ticothecium erraticum Massal. on Lecanora cinerea *M.*
Ticothecium rimosicolum Arn. on Rhizocarpum petraeum *M.*
Spegazzinia sp. on Pertusaria dealbata *S.*

PRESIDENTIAL ADDRESS.

By T. Petch, B.A., B.Sc.

FUNGI PARASITIC ON SCALE INSECTS*.

The earliest record of a fungus parasitic on a scale insect was made by Desmazières in 1848†. His specimens were collected at Caen, in Normandy, growing on scale insects on willow and ash. He instituted for it a new genus, *Microcera*, and gave a fairly complete description, emphasising the fact that the fungus was enclosed in a veil or sheath which divided into teeth at the apex. *Microcera* may be said to be a *Stilbum*, which has Fusarioid conidia, and is enclosed in a sheath which partly envelopes the head of conidia. Desmazières was so impressed by the structure and habitat of his species that he added to the formal description a long account of it in which he allowed his imagination free rein and compared *Microcera* to a phalloid.

Desmazières' species was next described by the Tulasnes in

* From the mycological standpoint, it is convenient to include the fungi parasitic on Aleyrodidae with those on the true scale insects (Coccidae).

† Ann. Sci. Nat., Ser. 3, 1. (1848), p. 359.

1861*. They did not find the universal veil, and stated that the apparent veil was merely a covering of mycelium at the base of the stroma. It would seem that they were misled by Desmazières' use of the term volva, and his comparison with a phalloid, and expected to find a structure resembling a phalloid volva at the base of the clava. It is difficult to make out the structure of *Microcera* from European examples.

Desmazières' fungus, *Microcera coccophila*, was a conidial form. To it the Tulasnes attached a perithecial stage, which was collected in company with a similar conidial stage at Florence. The perithecial stage was a *Nectria*, and consequently the Tulasnes placed the fungus in their genus *Sphaerostilbe*, under the name *Sphaerostilbe coccophila*. It is to be noted that the type locality for the perithecial stage is Florence, Italy, and that of the conidial stage, Caen, France.

The next record of a *Nectria* on a scale insect was made by Berkeley and Broome in the Fungi of Ceylon (1873)†, in which they described *Nectria aurantiicola*, with the note, "apparently growing from some coccus." Berkeley and Broome described the Fusarioid conidia and figured the effete Stilboid stage dividing into teeth at the apex; consequently, one is rather at a loss to understand why they did not place their species in *Sphaerostilbe*.

Two years later‡, Berkeley and Curtis described *Nectria aglaothele* from North America, with a note that it grew on the remains of a coccus. This again is *Sphaerostilbe*.

In 1901, Zimmermann described *Nectria coccidophthora*§, on scale insects in Java. This differs from *Nectria aurantiicola*, principally in its larger ascospores, and must be classed with the latter species in *Sphaerostilbe*.

So far the record is quite straightforward. Four species referable to *Sphaerostilbe* have been described as occurring on scale insects. But naturally, the idea that fungi might be parasitic on scale insects, and not on the plant on which they were found, was not always in mind, and hence it is only to be expected that, when the presence of the scale insect was not immediately obvious, such fungi would be described without reference to their real host. An examination of the species of *Nectria* and *Sphaerostilbe* in the herbaria at Kew and the British Museum has confirmed that supposition.

Prior to *Sphaerostilbe coccophila*, the Tulasnes had described a species with a similar conidial stage as *Sphaerostilbe flammea*. The history of the latter species begins in England, with speci-

* Selecta Fungorum Carpologia, I, p. 130; III, p. 105.
† Journ. Linn. Soc. XIV (1873), p. 117.
‡ Grevillea, IV (1875), p. 45.
§ Centralb. f. Bakt., Abt. II, VII (1901), p. 873.

mens collected by Ralfs at Penzance on living willows. These were described by Berkeley in 1854 as *Atractium flammeum* Berk. and Rav.*, the fungus having been found in similar situations, peeping up from beneath lichens, by Ravenel in South Carolina. Berkeley noted that Ravenel suspected it to be the state of some *Nectria*, and the herbarium specimens show that Ravenel had suggested that it was a stage of *Nectria muscivora* B. and Br.

Nectria muscivora was described by Berkeley and Broome† in 1851. It was parasitic on mosses at Kings Cliffe. To the description they added the note that they had the species from South Carolina on *Jungermannia*. There is an abundance of American specimens from Ravenel available in Herb. B.M. and Herb. Kew, under *Nectria muscivora*, and also others of the same species, either conidial, or conidial and perithecial, under *Atractium flammeum*, *Sphaerostilbe flammea*, and *Microcera coccophila*, identified by Berkeley or Ravenel.

Berkeley sent specimens of *Atractium flammeum* to the Tulasnes, and these proved to bear *Nectria* perithecia. Consequently the Tulasnes described it, first under the name *Stilbum flammeum*‡, and later as *Sphaerostilbe flammea*§. According to the Tulasnes, the specimens sent to them were American, though they stated that they grew on willow, which was the English host plant. Here we have another case in which the type locality for the conidial stage is in one country and the type locality for the perithecial stage in another.

This species was described again as *Nectria laeticolor* by Berkeley and Curtis in 1868‖; as *Nectria aglaothele* by the same authors in 1875¶, as *Nectria subcoccinea* by Saccardo and Ellis in 1882**, and as *Nectria Passeriniana* by Cooke in 1884††.

Ellis and Everhart discovered that *Nectria subcoccinea* was the same as Ravenel's specimens which had been attributed to *Nectria muscivora*, and they drew up their description of the latter species from specimens which had been distributed by Ellis as *Nectria subcoccinea*‡‡. But they did not see Berkeley and Broome's type of *Nectria muscivora*, and consequently were unaware that the original determination of Ravenel's specimens as *Nectria muscivora* was incorrect. That leaves *Sphaerostilbe flammea* as the earliest name for Ravenel's species, which is

* Ann. Mag. Nat. Hist., Ser. II, XIII (1854), p. 461.
† Ann. Mag. Nat. Hist., Ser. II, VII (1851), p. 188.
‡ Acta Hebdom. Acad. Sci. par. XLII, p. 704, and Ann. Sci. Nat., Ser. 4, V (1856), p. 114.
§ Selecta Fung. Carp. I, p. 130; III, p. 104.
‖ Journ. Linn. Soc. X, p. 377 (1868).
¶ Grevillea, IV (1875), p. 45.
** Michelia, II (1882), p. 570.
†† Grevillea, XII (1884), p. 81.
‡‡ North American Pyrenomycetes (1892).

not parasitic on mosses and lichens, but on scale insects which in some instances occur beneath mosses and lichens.

We have now to reconsider the species which has always been recognised to be parasitic on scale insects, viz. *Sphaerostilbe coccophila* Tul. This, it will be remembered, was instituted on a conidial stage, *Microcera coccophila*, collected in Normandy and a perithecial stage collected in Italy. Specimens of both these collections are available, and in both cases they contain perithecia. But the perithecia which accompany *Microcera coccophila* are not the same as those collected in Italy. The former are the perithecia of *Sphaerostilbe flammea*, while the latter are the species described from Ceylon by Berkeley and Broome as *Nectria aurantiicola*. Consequently *Microcera coccophila* Desm. is the conidial stage of *Sphaerostilbe flammea*, and *Atractium flammeum* is a synonym, while Tulasnes' *Sphaerostilbe coccophila* consists of the perithecia of one species and the conidial stage of another.

One has considerable hesitation in proposing to abolish a name which has become so firmly established in the literature of economic mycology. But *Sphaerostilbe coccophila* is a compound species and its name was admittedly selected on the mistaken supposition that the perithecia described were related to *Microcera coccophila*. In any case, *Microcera coccophila* must be retained for the conidial stage of *Sphaerostilbe flammea*, and it would be very confusing to retain the same specific name for the perithecial stage of a different *Sphaerostilbe*.

We have therefore three species of *Sphaerostilbe* parasitic on scale insects, viz. *Sphaerostilbe flammea, Sphaerostilbe aurantiicola*, and *Sphaerostilbe coccidophthora*. In their conidial, *Microcera*, stages, these are all very similar and it is scarcely possible to define any constant distinguishing characters. But their perithecia are sufficiently distinct to maintain them as different species.

Species of *Sphaerostilbe* on scale insects would appear to be rare in Europe. The European material available in English herbaria is fairly abundant, but it is the product of very few gatherings. Perhaps the position may be similar to that of *Hypocrella* and *Aschersonia* in the Tropics, i.e. the fungus only required to be looked for. Moreover, to one who has collected *Sphaerostilbe* on scale insects in the Tropics, all the temperate collections appear very poorly developed, especially as regards the *Microcera* stage. *Microcera coccophila* in Europe and the Northern United States usually does not exceed half a millimetre in height, but in the type of *Microcera pluriseptata* from Brazil, which is identical with *Microcera coccophila*, the synnemata attain a height of 2·5 mm.; and the same difference is

seen between *Microcera aurantiicola* from Italy and Ceylon respectively. One gains the impression that the temperate gatherings are depauperate examples of species which have wandered out of their proper latitude.

According to the specimens which I have been able to examine, the distribution of these species of *Sphaerostilbe* is as follows.

Sphaerostilbe flammea is chiefly an American species. It has been found in the United States—Massachusetts, Pennsylvania, Georgia, South Carolina, Louisiana, Florida and Texas—in Cuba, Brazil, and Argentina; in England, in the neighbourhood of Penzance; in Normandy in France; and in Liguria in Italy (*Nectria Passeriniana*). Conidial specimens from South Africa, Australia, and New Zealand appear to belong to this species but no perithecia are available; the first of these were described as *Fusarium coccinellum* (Kalch.) Thuem.*

Sphaerostilbe aurantiicola would appear to be the common species of the tropics, extending occasionally into temperate countries. I have examined specimens from Ceylon, India, Formosa, Japan, Madagascar, the West Indies, Georgia, Florida, and Italy.

Sphaerostilbe coccidophthora is at present known only from Java, Ceylon, India, and the Seychelles.

In general, these species of *Sphaerostilbe* are parasitic on *Lepidosaphes* (*Mytilaspis*), *Aspidiotus*, *Parlatoria*, *Diaspis*, *Chionaspis*, and allied genera of scale insects. They frequently occur on scale insects on Citrus, and it is to be expected that their natural distribution will have been extended by the transference of Citrus plants and fruits from one country to another.

Records of *Microcera coccophila*, and of *Microcera* in general, must all be regarded with caution, for the name *Microcera* has been employed to cover any conidial fungus with *Fusarium* spores which grew on a scale insect. One cannot, however, examine many gatherings of these conidial fungi before discovering that there are two common types which differ generically from one another. That fact was noted by Parkin† who characterised the difference by stating that the one form possessed an adherent sheath, while the other had a loose sheath. But Parkin, not having seen the European *Microcera*, referred the first of these, which is the true *Microcera*, to *Fusarium*, and the second to *Microcera*.

Microcera, in well-developed examples, has a *Stilbum*-like stalk composed of parallel hyphae, which separate at the apex, branch, and bear *Fusarium* conidia; the outer hyphae of the stalk are united into a continuous sheath, which is adherent to

* Thuemen, Mycotheca Universalis, No. 782.
† Annals R.B.G. Peradeniya, III (1906), p. 52.

the stalk, but separates into teeth and becomes free round the head of conidia; the sheath is inconspicuous, except after the conidia have been dispersed. The fructification is a synnema, and the genus falls in the *Stilbaceae*.

In the common form which has been confused with *Microcera*, the base of the fructification, in well-developed forms, is parenchymatous, and forms a more or less oval, red, cushion; at the upper edge of this there arises a ring of white teeth, like the margin of a Discomycete, but connivent, surrounding the apex of the cushion; the apex of the cushion bears closely packed conidiophores which produce *Fusarium* conidia. In this form, the sheath contrasts strongly with the base and, as a rule, is the most conspicuous feature of the fungus; it is not continuous with the basal cushion and differs in structure from the latter. The conidia of this form differ in shape from those of the species of *Microcera* which are parasitic on scale insects. This fructification must be classed in the *Tuberculariaceae*.

I have examined specimens of this form from Ceylon, India, Burma, Java, Mauritius, Australia, Formosa, the Philippines, West Africa, Grenada, Cuba, Florida, and Brazil. It has occurred on *Mytilaspis*, *Aspidiotus*, *Ischnaspis*, *Fiorinia*, and *Aonidia*. There are no constant differences between the specimens from different localities or on different scale insects, but the available specimens from West Africa have much longer conidia than those from other countries. As, however, the specimens, with few exceptions, are conidial only, it is perhaps advisable to regard the species as possibly a collective one. In America it has been referred to *Microcera coccophila*; in Formosa it has been named *Microcera Fujikuroi**; and from the Philippines, *Microcera Merrillii*†. As it is a common fungus, it is quite probable that it was named in the earlier days of mycology, without reference to its habitat. The earliest name yet discovered is that given it by Koorders in Java, viz. *Aschersonia Henningsii*‡. I propose to establish for this species a new genus, *Pseudomicrocera*, in which it will stand as *Pseudomicrocera Henningsii*.

In 1886 (?) Spegazzini described a *Nectria* which occurred on scale insects in Brazil as *Nectria coccorum*§, and in 1889, a second species, *Nectria coccogena*‖, from the same country. Through the kindness of Professor Spegazzini, I have been able

* Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v, pt. 3 (March 1913), pp. 73–90.

† Ann. Myc. XII (1914), p. 576. ‡ Bot. Untersuchungen (1907), p. 213.

§ Fungi Guaranitici, Pug. I, No. 234, Anal. Soc. Cientif. Argentina, Buenos Aires.

‖ Fungi Puiggariani, No. 289, Bolet. de la Acad. Nacional de Ciencias de Cordoba, II (1889), p. 381.

to examine the type specimens of both these species; that of *Nectria coccorum* is immature, but it appears to me to be identical with *Nectria coccogena*. Both the type specimens show a *Pseudomicrocera* conidial stage which is identical with *Pseudomicrocera Henningsii*. In Ceylon, this *Nectria* has been collected on two occasions, in each case developing on the old stromata of *Pseudomicrocera Henningsii*, and I have an immature gathering from Mauritius. *Pseudomicrocera Henningsii*, therefore, is the conidial stage of a *Nectria*. But the earliest name yet discovered for this *Nectria* is *Nectria diploa* B. and C., which was given to specimens from Cuba in 1875.

In 1901, Nomura published a paper* on the Scarlet Fungus Disease of Scale Insects in Japan, describing the fungus as a new species, *Nectria coccophila*. His paper was written in Japanese and has been generally overlooked, but in 1913 it was summarised by Miyabe and Sawada in their account of the fungi parasitic on scale insects in Formosa. Nomura, apparently, did not leave any type specimen, and the identity of his species is uncertain. Miyabe and Sawada would appear to favour the view that it was the species which they assign to *Sphaerostilbe coccophila*, but Nomura's description agrees more closely with *Nectria diploa*.

In 1913, Sydow† described a new genus and species parasitic on a scale insect in Japan as *Coccidophthora variabilis*. Subsequently K. Hara‡, who had sent the fungus to Sydow, stated that the specimen consisted of two species, viz. a *Nectria* parasitic on the scale insect, and a second species parasitic on the *Nectria*, and he described the scale insect *Nectria* as *Nectria variabilis*. I have not been able to examine a specimen of this *Nectria*, but from the published figures and the description it would appear to be again *Nectria diploa*.

A number of species have been described as *Microcera*, nine of which were said to be parasitic on scale insects. It is evident that the genus requires revision from the systematic standpoint, but at present only the scale insect species have been critically examined. Fortunately, most of the types of the latter have been available.

In 1904, McAlpine described§ two species of *Microcera* parasitic on scale insects in Australia, viz. *Microcera tasmaniensis* and *Microcera Mytilaspis*. The types of these species have been kindly lent me by Mr C. C. Brittlebank, and examination shows that they are identical, the first being a younger development of the second. This species proves to be neither *Microcera* nor

* Imp. Agric. Exp. Sta., Rep. 18 (1901), p. 105.
† Ann. Myc., XI (1913), p. 263.
‡ Botanical Magazine, Tokyo, XXVIII (1914), p. 339.
§ Agric. Journ. Victoria, II (1904), pp. 646–648.

Pseudomicrocera. It consists, in its fully developed form, of a stalked pezizoid disc, which bears *Fusarium* conidia. I propose to make this the type of a new genus, *Discofusarium*, with the species *Discofusarium tasmaniense*. Mr Brittlebank has also furnished me with specimens which show that the perithecial stage of this species is a *Calonectria*.

Of the remaining species of *Microcera*, parasitic on scale insects, *Microcera Parlatoriae* Trabut*, *Microcera Tonduzii* Pat.†, and *Microcera curta* Sacc.‡ are *Fusarium*. *Microcera rectispora* Cooke and Massee§ is *Tetracrium*, the conidial stage of *Ophionectria* (? *coccicola*); Cooke protested‖ that he made this species only in deference to the current opinion that minute differences in the spores were specific, but it would be difficult to imagine anything more different from *Microcera* than this.

In 1918, Stevenson¶ described another type of conidial fungus, *Tubercularia coccicola*, which was found on scale insects, *Lepidosaphes* and *Hemichionaspis*, in Porto Rico. Specimens have been kindly furnished by Stevenson, and they are, as far as can be determined, identical with a similar conidial fungus which occurs on scale insects in Ceylon and India. In the two latter countries, however, the perithecial stage has been found, and this, as might be expected, is another species of *Nectria*, which will be named *Nectria Tuberculariae*.

Another undescribed species of *Nectria* has been found on *Mytilaspis* on *Citrus* in Ceylon. This will be described as *Nectria barbata*. Its conidial stage is unknown.

Historical sequence has been discarded in this account, in order to bring together the recorded species of the same genus. We must now go back to 1886, when Ellis and Everhart** described a species, parasitic on scale insects on orange trees in Florida, as *Ophionectria coccicola*. Ellis and Everhart dealt with the perithecial stage only; Zimmermann††, who found the same species on *Parlatoria* in Java, supplied a description of the conidial stage in 1901. This conidial form is a very curious production. It consists of a short parenchymatous column, surmounted by a white, usually conical, head of conidia. The conidiophores are short moniliform chains of a few cells. At the apex, each conidiophore bears a cluster of two to five, long, lanceolate conidia, which falls off as a whole. The detached conidium is compound, and consists of a basal cell, the apical

* Bull. Agric. Alger et Tunisie, 1907, p. 32.
† Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‡ Ann. Myc., VII (1909), p. 437. § Grevillea, XVI (1888), p. 4.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Annual Rep., Insular Exp. Sta., Porto Rico for 1917.
** Journ. Myc., II (1886), p. 39; *ibid.*, p. 137.
†† Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.

cell of the conidiophore, from which arise from two to five long, lanceolate arms. There are usually three arms, and the whole conidium resembles the print of a bird's foot. It has been stated that the arms close up when the conidium dries, and expand again when it is wetted, so that the spore is propelled along the surface of a leaf, but I have not been able to observe that effect.

In 1902, Hennings* found a similar conidial fungus on scale insects on orange from Brazil and instituted for it a new genus, with the species *Tetracrium Aurantii*. Later, von Höhnel† re-examined Henning's specimen and discovered perithecia on it, of the same structure as *Ophionectria coccicola*. But he placed his species in the genus *Puttemansia* and transferred Ellis and Everhart's species to the same genus.

In 1910, Massee‡ described a scale insect fungus from Trinidad as *Scleroderris gigaspora*. No type specimen is available, but it is agreed that this was *Ophionectria coccicola*.

In 1913, Miyabe and Sawada§ described *Ophionectria tetraspora* on *Parlatoria* from Formosa. I have examined a specimen of this from Formosa, and it appears to me to agree with von Höhnel's description of *Puttemansia Aurantii*, but I have not seen the type of the latter.

A third species, co-generic with *Ophionectria coccicola*, has recently been found in Ceylon.

Puttemansia Aurantii is at present known only from Brazil and Formosa. *Ophionectria coccicola* is a widely distributed species, and I have seen specimens from Ceylon, Formosa, South Africa, Florida, and Dominica (W.I.), while it has been recorded correctly from Java. These species have occurred on scale insects belonging to the genera *Parlatoria*, *Aspidiotus*, and *Lepidosaphes* (*Mytilaspis*).

Ellis and Everhart placed their species in *Ophionectria*. Seaver transferred it to a recently-instituted genus, *Scoleconectria*‖. Von Höhnel considers that it belongs to *Puttemansia*, which is a genus founded by Hennings for a fungus he thought was a Discomycete. Consequently the nomenclature question has become somewhat complicated. It will be discussed fully in a later paper. But the three species of *Ophionectria*, *Scoleconectria*, or *Puttemansia* which are parasitic on scale insects agree with one another in having a *Tetracrium* conidial stage. Consequently, as far as these species are concerned, the simplest way of escape from the maze of nomenclature is to institute

* Hedwigia, XLI (1902), p. 116.
† Fragmente zur Mykologie, XIII (1911), pp. 27–30.
‡ Kew Bulletin, 1910, p. 3.
§ Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, V (1913), p. 85.
‖ Mycologia, I (1909), p. 198.

for them a new genus characterised by the possession of multiseptate ascospores and a *Tetracrium* conidial stage. It may be objected that genera of ascigerous fungi should not be founded on conidial characters, but we have a parallel case in *Sphaerostilbe*, which is merely a *Nectria* with a Stilboid conidial stage. For this new genus, I propose the name *Podonectria*, the species being *Podonectria coccicola* (E. and E.), *Podonectria Aurantii* (v. H.), and *Podonectria echinata*.

Zimmermann*, in his paper on scale insect fungi found in Java (1901), described *Lisea Parlatoriae* on *Parlatoria*, and *Broomella Ichnaspidis* on *Ichnaspis*. I have not met with any species of either of these genera on scale insects. From Zimmermann's description and figure, it is clear that the second of these is not a *Broomella*.

Among the fungi so excellently figured by the Tulasnes†, there is one, *Melanospora parasitica*, the nature of whose parasitism is doubtful. It is generally supposed to be parasitic on entomogenous fungi, and has been recorded on *Isaria*, on *Botrytis Bassiana*, and on *Cordyceps militaris*. But the Tulasnes figure it growing on a cockchafer, and it has been recorded as parasitic on *Lecanium hemisphaericum* in India‡. It has been found on *Icerya Purchasi* in Ceylon; in the latter country, it often occurs with *Cephalosporium*, but in several cases it appears to have attacked the insect independently of any other fungus.

In the genera, which are more usually associated with insects, viz. *Cordyceps* and *Torrubiella*, the number of species recorded as occurring on scale insects is comparatively small. In *Torrubiella* there are four species: *Torrubiella rubra* Pat. and Lagh.§, from Ecuador (1893), *Torrubiella luteorostrata* Zimm.*, from Java (1901), *Torrubiella brunnea* v. Keissl.‖, from Samoa (1909), and *Torrubiella Lecanii* Johnston¶ from Cuba (1918). In the case of the first three the species of scale insect is not recorded. Two species have been collected in Ceylon, on *Aleyrodes*, and Parkin** recorded a gathering on *Aspidiotus*. This genus has not yet been revised.

In the case of the genus *Cordyceps*, three species are said to occur on scale insects, but very little is known about two of them. In 1861, Berkeley and Broome described *Cordyceps pistillariaeformis*††, growing on a scale insect, apparently a *Lecanium*, on Wych Elm at Batheaston. Apparently only two

* Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.
† Selecta Fungorum Carpologia. ‡ Ann. Myc., IX (1911), p. 392.
§ Bull. Soc. Myc. France, IX (1893), p. 154.
‖ Micromycetes in Bot. u. Zool. Ergebnisse, Samoa Inseln, von Karl Rechinger.
¶ Mem. Soc. Cubana Hist. Nat. "Felipe Poey," III (1918), p. 80.
** Ann. R.B.G. Peradeniya, III (1906), pp. 18, 19.
†† Ann. Mag. Nat. Hist., Ser. 3, VII (1861), p. 451.

specimens were found, one conidial, and the other perithecial, but immature. From the herbarium collections, this species does not appear to have been found again in Britain. Prior to that, in 1834, Schweinitz had described *Sphaeria clavulata* in his Synopsis of North American fungi*. In 1869, when Berkeley and Curtis enumerated the fungi of Cuba†, they listed *Sphaeria clavulata* as a *Xylaria*, adding the extra-Cuban localities, North America and Venezuela. Subsequently, Peck stated that Schweinitz' *Sphaeria clavulata* was a *Torrubia*‡, or, as we should now call it, a *Cordyceps*, and Ellis and Everhart§ state that it is quite certain that the *Cordyceps* distributed by Peck is the genuine *Sphaeria clavulata*. It has been collected in America on several occasions, and is parasitic on *Lecanium*. Cooke‖ considered that *Cordyceps pistillariaeformis* B. and Br. is identical with *Cordyceps clavulata* (Schw.) E. and E., and Massee, Ann. Bot. IX (1895), p. 22, agreed with him. That view is most probably correct, but one would wish for further material of the British species before coming to a final decision. The herbarium specimens show some differences, which may however prove to be intraspecific. Berkeley's specimen of *Xylaria clavulata* from Cuba is a very immature *Xylaria*, and has little resemblance to *Cordyceps clavulata*.

The other species of *Cordyceps*, said to occur on a scale insect, is *Cordyceps coccigena* (Tul.) Sacc.¶, described and figured by the Tulasnes. It was collected in New Guinea, and was said to be growing on a coccus. As in the case of so many collections of these entomogenous fungi it was immature. However, from the excellent illustration, one is led to doubt the statement that it was growing on a coccus. The insect is large for a scale insect, and the figure shows that the body consisted of at least two distinct segments. Two clavae, with depressed globose heads, arise from the foremost segment. Except that the anterior segment is covered with mycelium, the illustration is good for *Cordyceps dipterigena* B. and Br., and I would hazard the suggestion that *Cordyceps coccigena* really grew on a fly.

In the case of the species which have already been mentioned, there is usually no doubt that the fungus is growing on a scale insect. It does not obliterate the insect. It generally grows out from the insect and produces its conidiophores at the margin of the scale and its perithecia in the same position or on the top of the scale. In *Podonectria*, there is a byssoid stroma

* Trans. American Philos. Soc., IV (1834), pp. 141–316.
† Journ. Linn. Soc., X (1869), p. 380.
‡ 28th Rep. New York State Museum.
§ North American Pyrenomycetes.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Selecta Fungorum Carpologia, III, p. 19, Tab. I, fig. 10.

which may spread over several scales, and in *Torrubiella* a similar stroma may cover the greater part of a colony of insects, but the scales are usually clearly evident. In the largest group of scale insect fungi, however, conditions are different; in it, each individual fungus grows over a single insect, and, as a rule, not only hides it completely, but consumes the whole of it, so that there is no trace of the insect left within the stroma. Therefore, it is not surprising that the first fungi recorded as parasitic on scale insects belonged to the *Sphaerostilbe* or *Nectria* group, while the species of the larger group, *Hypocrella* and *Aschersonia*, were described without reference to any host, except the plants on which they occurred.

The genus *Aschersonia* was founded by Montagne* in 1848 for two species, supposed to be phyllogenous, one from Guiana and the other from Tahiti. They were pycnidial fungi, brightly coloured, and evidently allied to the *Hypocreaceae*. In 1884, Saccardo† enumerated nine species; by the year 1900, the number had increased to 26; and at the end of 1919, there were 60.

It was not discovered that species of *Aschersonia* were entomogenous until 1894, when Webber‡, who had studied the fungi and insects which occurred on *Citrus* in Florida, demonstrated that *Aschersonia aleyrodis* was parasitic on *Aleyrodes citri* R. and H., *Aschersonia turbinata* on *Ceroplastes floridensis*, and, judging from his figures, *Aschersonia cubensis* on *Lecanium hesperidum* L. Webber suggested that all species of *Aschersonia* would be found to be entomogenous, but his results did not have any immediate influence on systematic mycology. Hennings§ described five species of *Aschersonia* from Java in 1902, and called attention to the remarkable phenomenon that these fungi generally occurred with various species of *Lecanium*, to which they bore so great a resemblance in form and colour that he considered the association should be regarded as a case of mimicry. Parkin‖, in 1906, supported Webber's view, and recorded eight gatherings of *Aschersonia* parasitic on *Aleyrodes* and seven gatherings on *Lecanium*; from the specimens left by him, these included *Aschersonia placenta*, *Aschersonia confluens*, *Aschersonia hypocreoidea*, and *Aschersonia samoensis*, on *Aleyrodes*, and *Aschersonia Coffeae* and *Aschersonia marginata* on *Lecanium*. Since 1904, new species of *Aschersonia* have generally been described as occurring on scale insects or *Aleyrodidae*; and at the present time, all species which are true *Aschersonia* in structure are known to be entomogenous.

* Ann. Sci. Nat., Ser. 3, x, p. 122. † Sylloge Fungorum, III, p. 619.
‡ U.S.A. Dept. Agric., Div. Veg. Physiol. and Pathol., Bull. 13 (1897).
§ Hedwigia, XLI (1902), pp. 145, 146. ‖ *Op. cit., supra.*

Species of *Sphaerostilbe* and *Nectria* attack *Lepidosaphes* (*Mytilaspis*), *Chionaspis*, *Aspidiotus*, *Fiorinia*, and allied insects. Species of *Aschersonia*, on the other hand, attack only insects belonging to the families *Lecaniidae* and *Aleyrodidae*. Moreover, there is a notable difference between the species parasitic on the two families respectively: those parasitic on *Aleyrodidae* have paraphyses in the pycnidium, while those parasitic on *Lecaniidae* have no paraphyses. It is curious that of Montagne's two species, *Aschersonia taitensis* is aleyrodiicolous, while *Aschersonia guianensis* is lecaniicolous.

The perithecial stage of *Aschersonia* is *Hypocrella*, and as might be expected, it also is entomogenous. The earlier mycologists included species of *Hypocrella* in *Hypocrea*, from which it differs in having long filiform spores which divide into rod-shaped, or oval, part-spores in the ascus. *Hypocrella* was split off in 1878 by Saccardo*, who placed in it four species, only one of which, the type species, now remains in the genus. Ten species were enumerated by Saccardo† in 1883, but the number described up to the end of 1919 is seventy (including *Fleischeria* and *Moelleriella*).

In general, species of *Hypocrella* so closely resemble the corresponding species of *Aschersonia* that it is not possible to decide which a given stroma is without sectioning it. Yet it was apparently not until 1896 that any relationship between the two was suggested. In that year, Massee‡ stated that he had examined Berkeley's specimen of *Aschersonia oxyspora* and found that it was a *Hypocrella*, Berkeley having mistaken the part spores for *Aschersonia* spores. He had also examined part of Montagne's type of *Aschersonia taitensis*, the type species of the genus, and had found that the young stromata were covered with a dense stratum of fusiform spores while "the primordia of perithecia were very evident in the substance of the stroma." Hence he suggested that "in all probability the genus *Aschersonia* will prove to be nothing more than the conidial form of *Hypocrella*."

I have not been able to trace any further observations on this point by Massee, but three years later, in his Textbook of Plant Diseases (1899), he wrote, "I have shown that species of *Aschersonia*, which hitherto were only known to produce a conidial form of reproduction on living leaves, produce an ascigerous form of fruit, following the conidial stage, on fallen dead leaves."

Massee's hypothesis, that *Aschersonia* is the pycnidial stage of *Hypocrella*, is undoubtedly true, but the observations which

* Michelia, I, p. 322.
† Sylloge Fungorum, II, p. 579.
‡ Journ. of Botany (1896), p. 151.

he cited in support of it are not correct. *Aschersonia oxyspora* Berk. is an *Aschersonia*, and its *Hypocrella* stage was unknown until recently collected in Ceylon. In *Aschersonia taitensis*, the stromata are not covered with spores; they bear discontinuous spore masses which have oozed out of the pycnidia, and the supposed primordia of the perithecia are the pycnidia in which they were produced. Moreover, no case is known in which the pycnidial form is followed by the development of an ascigerous form on dead fallen leaves. When the leaf falls, the fungus decays.

In general, an *Aschersonia* stroma does not subsequently become perithecial. Exceptions to that rule may be found in *Aschersonia turbinata* and *Aschersonia placenta*. But effete *Aschersonia* stromata usually decay, even when on living leaves, or stems. In some gatherings, all the stromata will be *Aschersonia*, in others all *Hypocrella*, and it has not yet been possible to determine what conditions govern the production of either stage. Just as, in *Sphaerostilbe*, the *Microcera* stage is commoner than the *Nectria* stage, so the *Aschersonia* stage is much more frequent than the *Hypocrella* stage.

How, then, is it possible to correlate species of *Aschersonia* with their *Hypocrella* stages? Simply by finding, as Massee thought he had, both stages in the same stroma. Instances do occur in which a stroma is, at the same time, pycnidial and perithecial, and one has to wait until they turn up.

The first definite proof of Massee's theory was provided by Möller*, who found both stages in the same stroma in *Hypocrella cavernosa*. Möller also observed that *Aschersonia basicystis* was similar in shape, etc., to *Hypocrella phyllogena*, and recorded that Lindau had found both stages in the same stroma in specimens sent him from Brazil. Zimmermann† described both stages in *Hypocrella Raciborskii*, and Thaxter‡ has found both in *Hypocrella turbinata*, while during a recent revision of these two genera, both stages have been found in the same stroma in the case of eleven other species.

As I have already stated, 70 species of *Hypocrella* and 60 species of *Aschersonia* have been described. In revising these genera, it has been necessary to make seven new species and to transfer four from other genera. Nevertheless, the total number of valid names is only 54, covering 42 species. In the group parasitic on *Lecanium*, there are at present, 20 species of *Hypocrella*; the corresponding *Aschersonia* is known in eleven cases, and in six of these it has received a name. In the group parasitic on *Aleyrodes*, there are nine species of *Hypocrella*; the

* Phycomyceten und Ascomyceten, 1901.

† *Op. cit., supra.*

‡ Botanical Gazette, LVII, pp. 308–313.

Aschersonia stage of each of these is known, and in six cases it has been named, while there are in addition 13 unattached Aschersonias.

Hypocrella and *Aschersonia* occur on living leaves and stems, on which they form superficial, easily detached stromata. The stromata are usually brightly coloured—white, yellow, red, or brown—and may be subglobose, hemispherical, flattened pulvinate, or scutate. As a rule, they do not exceed 3 mm. in diameter, but one giant from Brazil, *Hypocrella Gartneriana*, is said to attain a diameter of 3 cm. The stroma is composed of thick-walled hyphae and in the species parasitic on *Lecanium* it is usually very hard and sclerotioid. Penzig and Saccardo* instituted the genus *Fleischeria* for the harder species of *Hypocrella*, and, while it is scarcely possible to consider hardness a generic distinction, the name can be associated with a morphological character, as it was applied to a *Hypocrella*, whose *Aschersonia* stage has no paraphyses, whereas in the type species of the genus *Hypocrella*, the *Aschersonia* stage has paraphyses. This sclerotioid character is no doubt to be correlated with the fact that these fungi are superficial, and, not being able to obtain water from the leaf, must be able to withstand periods of drought. It is shared by several other fungi in the tropics which overrun leaves and twigs: the common Thread Blights, for example—white, normal-looking mycelia which occur on the upper parts of bushes and trees—are composed chiefly of sclerotioid hyphae.

One peculiar species, *Hypocrella scutata*, which has been found in Singapore and the Philippines, has a stroma composed chiefly of resin in which the hyphae are embedded. It breaks with a vitreous fracture, and if a lighted match is applied to it it burns like resin. Failing any other explanation, one is led to assume that this peculiarity is due to the insect on which it is parasitic, but it has not been possible to verify that assumption.

In all the collections of *Hypocrella* and *Aschersonia* which I have examined, whenever it has been possible to identify the insect, the latter has belonged to the *Lecaniidae* or to the *Aleyrodidae*. *Aschersonia Coffeae* has been recorded† as occurring on *Aspidiotus*, and *Aschersonia marginata* on *Parlatoria*, but these records are probably erroneous. It is necessary to exercise great caution in deciding what insect a *Hypocrella* is parasitic upon. If a *Lecanium* and a *Lepidosaphes* occur together on the same leaf, a lecaniicolous *Hypocrella* may destroy all the individuals of the *Lecanium*, leaving only the *Lepidosaphes*.

Another ascigerous genus, which occurs on scale insects

* Malpighia (1901), p. 230.

† Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v (1913), pp. 73–90.

throughout the tropics, forms black, irregular stromata over or at the side of the scale, and often extending some distance from it. This is *Myriangium*. The stroma is parenchymatous, without true perithecia, but with asci embedded singly in the tissue. The spores are muriform. It was first recorded on scale insects by Zimmermann* in Java in 1901, and has since been found on them in Ceylon, Florida, the West Indies, etc. Some doubt has been expressed concerning the parasitism of this group, because it frequently occurs in company with *Sphaerostilbe*, but the explanation of that would appear to be that it attacks the same species of scale insects as the latter. In many instances it is the only fungus present.

Mr Ramsbottom has pointed out to me that *Myriangium* has been known to be a British genus for more than half a century, though it has not been included in lists or textbooks of British fungi. When Berkeley described the genus†, he stated that it was allied to *Collema*; hence it was at first included among the lichens. Subsequently, it was discarded by the lichenologists, and the mycologists omitted to take it up. Specimens of *Myriangium* were collected in abundance during the Foray on *Chionaspis salicis* on Ash, and effete stromata have been gathered on the same host in Norfolk and Yorkshire.

It is customary to refer the species of *Myriangium* found on scale insects to *Myriangium Duriaei* Mont. and Berk., the type species of the genus, originally recorded in 1845 from the Pyrenees, Algeria and Australia, but the examination of the numerous gatherings of this genus now available has not yet been completed. *Myriangium Acaciae* McAlp. is entomogenous.

Myriangium is generally placed in the *Plectascineae*, in the subfamily *Myriangiaceae*. Von Höhnel‡, who has recently revised the subfamily, considers that the latter should be placed in the *Dothideales*. *Myriangiaceae* has been a convenient centre for little-known genera of doubtful affinities, and von Höhnel has found it necessary to reduce the 23 genera hitherto included in it to five, either by synonymy or exclusion. Apparently 12 species now remain in *Myriangium*. It remains to be determined how many of these are valid, how many are entomogenous, and whether any of the other genera of *Myriangiaceae* which have superficial stromata are entomogenous.

As recorded by Parkin§, a black stromatic fungus, somewhat resembling *Myriangium*, but pycnidial, is found on *Mytilaspis* in Ceylon. It usually has prominent pycnidia, which contain small, brown, narrow-oval spores. Parkin suggested that this

* *Op. cit., supra.* † Hooker's Lond. Journ. Bot., IV (1845), p. 74.
‡ Fragmente zur Mykologie, VI Mitt. (1909), pp. 75–102.
§ *Op. cit., supra.*

is a pycnidial stage of *Myriangium*, but that has not yet been verified.

No species of the *Entomophthoreae* was known on scale insects prior to 1918, when an *Empusa*, *Empusa Lecanii*, was recorded* on scale insects on coffee in Mysore.

The list of families which are known to provide entomogenous fungi was extended by a remarkable addition in 1907, when von Höhnel† announced his discovery of scale insects beneath the stroma of a *Septobasidium*. That has since been repeated‡ in Ceylon (where all the known species of *Septobasidium* appear to be entomogenous), in Japan, and on specimens from India and Canada.

Species of *Septobasidium* are common in the tropics, where they occur on the stems, and sometimes on the leaves, of living plants, without, as a rule, causing any apparent injury. The commoner species have a peculiar structure. They first cover the stem with a thin adherent stroma, from which arise numerous erect bristles or fascicles of hyphae. Another continuous layer is then developed over the tops of the bristles, so that the structure is two-storied, the upper storey being supported on pillars. The hymenium is developed on the surface of the upper layer. If the fungus is examined in an early stage of development, the remains of the scale insects will be found beneath the initial layer of the stroma. The fungus grows over and kills whole colonies of scale insects, and completely covers the stems of the host plant.

In Ceylon, *Septobasidium rameale* (Berk.) Bres. is frequent on orange trees infested with *Mytilaspis*, sometimes clothing all the stems for a length of several feet and spreading from them over the leaves. A species, allied to *Septobasidium pedicellatum* (Schw.), attacks scale insects on tea, and in some cases covers all the stems of a tea bush. Another species which is found on tea is usually associated with *Chionaspis*. The tea planter is often alarmed when he finds these fungi covering his bushes, but, in general, they are harmless. There are, however, exceptions to the rule. Some species, after destroying the scale insects, attack the plant. That happens in the case of an undetermined species on tea in Ceylon, the species which causes the disease known as Velvet Blight on tea in Northern India, and several species on tea and mulberry in Japan§.

Several species of Hyphomycetes have been recorded as parasitic on scale insects. One of the most interesting of these is a

* Dept. Agric. Mysore, Ento. Series, Bull. 4.

† Sitzungsber. d. Kais. Akad. d. Wissensch. Wien, Math. Naturw. Kl., CXVI (1907), p. 740.

‡ Annals of Botany, XXV (1911), p. 843.

§ Mycologia, X (1918), pp. 88–90.

Fusarium, which was originally described as parasitic on *Aspidiotus Aurantii* in Australia by McAlpine* in 1899 under the name of *Fusarium epicoccum*. Its conidia are variable, sometimes nearly straight, sometimes hook-shaped, but the typical conidium is stout, short, three-septate, and curved to two-thirds of a circle. It was named *Microcera Parlatoriae* by Trabut† in 1907 from specimens on *Parlatoria* on orange in Algeria, *Microcera curta* by Saccardo‡ in 1909 from specimens on a scale insect on *Tilia* in Germany, *Microcera Tonduzii* by Patouillard§ in 1912, from specimens on *Ficus* from Costa Rica, and *Fusarium Aspidioti* by Sawada‖ in 1914 from specimens on *Aspidiotus* on *Pyrus* in Japan. The interesting point about this *Fusarium* is that the short, curved conidium exactly resembles one of the forms of conidia described by Berkeley and Broome as part of *Sphaerostilbe aurantiicola*. It occurs quite commonly with *Sphaerostilbe aurantiicola* in Ceylon, but I have never been able to detect the sporodochium in any of my numerous gatherings of that species. One mounts the ordinary *Microcera* synnema, or an isolated perithecium, and finds the small curved conidium on the slide. It apparently occurs on the slight weft of mycelium at the base of the perithecium. It is abundant in the perithecial specimens collected at Florence in 1860. I was formerly inclined to regard this conidium as typical of *Sphaerostilbe aurantiicola*, but I have found it a specimen of *Sphaerostilbe flammea* from Georgia, Ravenel 3376. The question then arises whether *Fusarium epicoccum* is a stage of *Sphaerostilbe*, or whether the conidia found with the *Sphaerostilbe* are intrusive. Against the first theory, there is the fact that all the collections of the *Fusarium*, with one exception, contain only the *Fusarium*, and the exception is such a mixture that nothing can be deduced from it, as it includes *Sphaerostilbe*, *Pseudomicrocera*, and *Podonectria* on the same leaf. Against the second, we have the absence of any gathering of the *Fusarium* sporodochium from Ceylon.

Another *Fusarium*, *Fusarium coccidicola*, was described by Hennings¶ in 1903 from specimens on tea collected in German East Africa. I have not seen the type, but from the description it would appear to be *Pseudomicrocera*.

A Hyphomycete, which is of considerable economic importance in the Eastern Tropics, was described by Zimmermann** in 1898

* Fungus diseases of Citrus trees in Australia, 1899.
† Bull. Agric. Alger et Tunisie, 1907, p. 32.
‡ Ann. Myc. VII (1909), p. 437.
§ Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‖ Bot. Mag., Tokyo, XXVIII (1914), p. 312.
¶ Engler's Bot. Jahrb. (1903), p. 57.
** Over eene Schimmelepidemie der groene Luizen, Buitenzorg, 1898.

as *Cephalosporium Lecanii*. It is known to occur in Java, Ceylon, and India. In Ceylon, it has been found on several species of *Lecanium*, but it is especially common on *Lecanium viride*, the common scale insect pest of coffee. Indeed, during the rainy seasons, *Lecanium viride* appears to be invariably attacked by this fungus. Recently, it has been found to attack *Icerya Purchasi* in Ceylon, and up to the present it appears to have effectively controlled that insect.

Similarly, *Hyalopus Yvonis* Dop (1905) is said* to have controlled an *Aspidiotus* which was causing great damage to coco-nut palms in Martinique. As *Hyalopus* is not very different from *Cephalosporium*, this species needs comparison with *Cephalosporium Lecanii*.

Other Hyphomycetes which have been found on scale insects are *Acrostalagmus coccidicola* Guéguen (1904) on a coccus on a shrub at the Paris Exhibition of 1900; *Geotrichum coccophilum* Speg., on a coccus on *Cycas revoluta*, Brazil; *Acremonium araucanum* Speg., on *Aspidiotus*, Chili; *Stilbum coccophilum* Sacc., and *Penicillium coccophilum* Sacc., on *Ceroplastes* in the Botanic Garden, Palermo; *Sporotrichum Lecanii* Peck, on *Lecanium* in North America; *Sporotrichum globuliferum* Speg., on *Lecanium hesperidum* at Lisbon†; *Verticillium heterocladum* Penz., on *Lecanium hesperidum* on orange, in Italy. This group has not been critically examined.

In addition to the identifiable fungi enumerated, a number of sterile stromata occur on scale insects. Some of these appear to belong to *Septobasidium*. A small purple red lenticular stroma, which is common in the Eastern Tropics, apparently belongs to *Torrubiella*. Others seem to belong to *Aschersonia*. There is some evidence that these stromata are sterile because they have been attacked by another fungus, e.g. *Cladosporium*, but this phase of the subject is still under investigation. The brown sterile fungus found on scale insects in Florida has been found to be an *Aegerita*, *Aegerita Webberi*; according to the specimens submitted to me, it is not a state of a *Meliola*.

All the fungi which have been mentioned ultimately make their appearance on the exterior of the scale insects attacked. There is however another class of fungi which are entoparasites. The first of these to be discovered was observed by Leydig in *Lecanium hemisphaericum* in 1854, but their nature was not recognised until 1887 when Monier‡ described *Lecaniascus polymorphus*, parasitic on *Lecanium hesperidum*. During the current century, considerable attention has been given to this group,

* Bull. Scient. France et Belgique, XXXIX (1905), p. 135.

† Camara Pestana, J., Bull. Soc. Portugaise Sci. Nat. Lisbonne, II (1908), pp. 14–18.

‡ Bull. Soc. Zool. France, XII (1887), pp. 150–152.

and about ten species have been described*, parasitic on *Lecanium*, *Pulvinaria*, *Aspidiotus*, *Chermes*, *Physokermes*, *Aleurodes*, *Icerya* and *Dactylopius*. The majority of these belong to the Saccharomycetes. This group is one which invites the attention of British mycologists, as all the existing records have been made in temperate countries—France, Italy, Bohemia, and Germany.

The list of fungi which are parasitic on scale insects is already a long one, but there is every probability that it will be still further extended. The majority of the species are essentially tropical, and when more is known about the biology of tropical fungi, new forms may be expected to be added. From the specimens available in herbaria, these fungi would be considered rare, but it is generally possible, at least in Ceylon, to collect them in large numbers by searching specially for them. I have seen a tree of the Ceylon Patna Oak (*Schleichera trijuga*), on which nearly every leaf bore *Aschersonia placenta*, in some cases so crowded that the stromata had fused into a continuous sheet. The discovery of a single *Aschersonia* usually leads to the collection of dozens, or sometimes hundreds, if the bush is systematically examined, though of course disappointments do occur.

No one who has collected these fungi in the tropics can fail to be impressed by the enormous destruction of scale insects which they bring about. A *Septobasidium* will wipe out all the insects on a badly-infested orange tree or tea bush. *Cephalosporium Lecanii* will attack *Lecanium viride* on coffee over the whole of an estate. I have spent a morning in a Ceylon jungle which consisted almost entirely of Ebony trees, collecting *Aschersonia placenta* on the Ebony leaves, and have not been able to find a single specimen of the Aleyrodid on which it grew: the insect had been obliterated over an area of several acres. Again, in the jungle above Hakgala, *Aschersonia oxystoma* is common on the shrub, *Sarcococca pruniformis*, but although I have collected it there periodically for several years, I have not been able to determine what scale it is parasitic on. When a scale insect on a particular tree is attacked by a fungus, its destruction is so complete that one wonders how the species manages to survive.

Under such circumstances, it is not surprising that attempts have been made to control the scale insect pests of economic plants by means of entomogenous fungi. The best known of these, in fact the only attempts which have been conducted on an experimental basis, have been carried out in Florida, where, since about 1896, the use of *Aschersonia Aleyrodis* and

* See Buchner, Arch. Protistenk. xxvi (1912), pp. 1–116.

Aschersonia Goldiana has been recommended for the control of *Aleyrodes*, and *Sphaerostilbe, Pseudomicrocera*, and *Podonectria* for the control of *Aspidiotus, Lepidosaphes*, etc. For several years, these were regarded as the sole instances of successful control of insects by the use of entomogenous fungi, though adverse criticism was not lacking. Finally, the United States Bureau of Entomology undertook a special investigation into the subject, and the results of four years enquiry and experiment have been published by Messrs Morrill and Back* in a Bulletin entitled, "Natural Control of White Flies in Florida," from which the following extracts are quoted.

"Much damage has resulted in the past from ill-advised attempts to check the spread of white flies in newly infested localities by means of fungus parasites. The control of destructive diseases affecting citrus trees has been interfered with by (these) fungus parasites and much preventable loss thereby incurred. This interference is due to the fear that the fungicides recommended for the diseases referred to, would, if applied to the trees, check the white fly fungus parasites with injurious results.

"Under natural conditions, without artificial assistance in spreading, the fungi have ordinarily in favoured localities, controlled the white fly to the extent of about one-third of a complete remedy through a series of years.

"The most successful method so far devised for introducing the red and yellow Aschersonias into groves where they do not occur is the spore spraying method, first successfully employed and recommended by Dr E. W. Berger. For the introduction of the brown fungus the brushing or dipping and the rubbing methods first used by the authors are as successful as any yet discovered, but are not so reliable as the spore spraying methods for the Aschersonias. The infections secured by artificial means of introducing fungi, while successful in introducing the fungi, have thus far proved of little or no avail in increasing their efficacy after they have once become generally established in a grove. Experiments by the authors, and by citrus growers in co-operation with the authors, involving the treatment of thousands of trees with suitable 'checks' or 'controls' have shown that when fungus (red or yellow *Aschersonia*) even in small quantities is present in a grove there is no certainty that from three to six applications of fungus spores in water solution will result in an increased abundance of the infection on the treated blocks of trees by the end of the season. In some of the most important and carefully planned and executed experiments the fungus has increased more rapidly in sections of

* U.S. Dept. of Agric., Bureau of Entomology, No. 102.

the groves which were not sprayed with spore solutions than in the experimental blocks. In no case has practical benefit been observed to result from efforts to increase the efficiency of the fungi in groves where they previously occurred. The above remarks apply especially to the Aschersonias. With the brown fungus, efforts to increase the efficacy have been equally disappointing from a practical standpoint.

"As a result of the investigations reported herein and of observations and experience covering a period of four years the authors conclude that there are at present no elements of natural control herein dealt with which can be relied upon to give satisfactory results. Under present conditions it is unquestionably more profitable to depend upon artificial remedies."

The Florida results thus agree with those of other experiments of the same character, and at the present day after 30 years' trial there is no instance of the successful control of any insect by means of fungus parasites. If the entomogenous fungi already exist in a given area, practically no artificial method of increasing their efficacy is possible. If they are not present, good may result from their introduction, if local conditions are favourable to their growth, but, on the other hand, their absence would appear to indicate unfavourable conditions.

It would seem that a fungus makes little progress until the insects are excessively numerous, either locally or generally, when for reasons not known an epidemic of fungus disease breaks out. And in this connection it may be noted that the apparently successful experiments in inducing a more rapid dissemination of an entomogenous fungus have usually been made during such an epidemic.

Morrill and Back's statement that *Aschersonia Aleyrodis*, etc., have controlled the white fly to the extent of about one-third of a complete remedy is apparently to be interpreted that an epidemic of fungus disease among the scale insects occurs every three years. Where an insect is always present, these epidemics appear to occur at definite intervals; and where the occurrence of the insect is discontinuous, they appear to occur at a definite period from the first appearance of the insect. The Wilt disease of the Tea Tortrix of Ceylon (*Homona coffearia*), though not a fungus disease, gives a notable illustration of that. The occurrence of that insect as a pest is discontinuous. In the first year of its appearance in any locality, the insect increases without any check; in the second year, Wilt disease attacks a small proportion of the caterpillars; in the third year, it practically kills out every one. In the case of *Cephalosporium Lecanii* on *Lecanium viride* on coffee in Ceylon, an epidemic of fungus disease occurs in the same locality during each rainy season;

in that case the controlling factor is probably climatic. On the other hand, in a small plantation of mulberry trees at Peradeniya, it is always possible to find *Sphaerostilbe aurantiicola* in the rainy season, but only on a few trees, though a large number of trees may be attacked by the same scale insect; in that case, some other than climatic factors must be involved.

The problem which has yet to be solved by those who wish to control insects by means of fungi is how to create an epidemic at a time when such an epidemic would not occur naturally. The evidence indicates that it is not possible to accomplish that by the mere introduction of the fungus or by spraying spores from natural or artificial cultures. The solution of the problem probably depends in each case upon a study of the bionomics of the insect, and it is satisfactory to note that the United States Department of Agriculture has appointed a Myco-entomologist specially to investigate these diseases of insects.

I should like to make my position on this point clear. I do not for one moment wish to deny that it may be possible ultimately to discover what factors govern the incidence of these diseases of insects, and that, in consequence of such discovery, it may be possible to utilise them to control insect pests. But I do hold that, in the present state of our knowledge, after nearly thirty years of investigation and experiment, there are no facts which would warrant the recommendation of any such means of control.

Though the majority of the scale insect fungi are tropical, there is some work to be done on them in the British Isles. We require more material of *Cordyceps pistillariaeformis*, which has occurred on a *Lecanium* on elm. *Sphaerostilbe flammea* is apparently rare in Britain, but it should be sought for in the winter on *Chionaspis salicis* on willow and ash. The insect is especially abundant on ash, coppiced ash in hedge rows being generally badly infested. *Fusarium epicoccum*, not yet recorded as British, should be found in the same situation, and it might be possible to determine its perithecial stage. A *Verticillium* has recently been collected on the same host in Yorkshire; it forms a delicate white mould over the colony of scale insects.

With the exception of the *Cordyceps*, all the scale insect fungi found in Britain have occurred on *Chionaspis*. In the tropics, *Aspidiotus* and *Lepidosaphes* are the favourite hosts of the *Nectria* group, and it should be possible to find species on the common scale insects of fruit trees in Britain, if search is made for them in the winter.

THE SPORULATION OF GONIDIA IN THE THALLUS OF EVERNIA PRUNASTRI ACH.

With Plate I.

By Robert Paulson, F.L.S.

Evernia prunastri, one of the most widely distributed of the British fruticose lichens, occurs frequently, sometimes abundantly, on trunks and branches of trees in woodlands and hedgerows; less often on rocks, walls, palings and bare sandy soil. Its much branched flaccid thallus is decumbent or pendulous in habit except in the early stages of growth when it is more or less erect. A form *retusa*, recorded from a small number of localities, consists solely of dense tufts of erect fronds (11). In colour it is grey-green above and paler or whitish beneath. The branches are compressed and are frequently white-sorediate at the margin, the broader, older ones, being reticulate on the upper surface and finely, longitudinally channelled below. They terminate in two flattened points, which, after a period of further growth, fork again in a similar manner and thus exhibit the characteristic appearance of dichotomy. The apothecia, rarely produced, are large, sub-pedicellate and dark brown. They sometimes have a disc measuring as much as 12 mm. across; the margin is prominent and involute.

Before cutting the sections from which the preparations, to be described later, were made, small portions of the thallus were placed in a weak chromo-acetic fixing solution for at least twenty-four hours; a longer period does no harm. After thoroughly washing for two hours, the material was passed into paraffin wax in the ordinary way. Heidenhain's iron-alum-haematoxylin and Delafield's haematoxylin were the staining reagents employed. Permanent mounts were as a rule put up in Canada balsam, but these do not show the cell wall sufficiently defined for all purposes, so that when preparing gonidia in the various phases of division, it was found advisable to mount some sections in glycerine, by which method the newly formed cell wall of a daughter gonidium is rendered distinctly visible (fig. 2).

The portion of the thallus most favourable for obtaining large numbers of actively dividing gonidia is that part situated at from four to five millimetres below the apex of a young branch. In early spring, and in showery weather after a prolonged drought, numerous dividing gonidia can be found in all growing parts.

A transverse section of the thallus taken more than a centimetre from the end of a branch exhibits a dorsiventral structure consisting of the following differentiated layers, (*a*) upper cortical layer, (*b*) gonidial layer, (*c*) medulla, and (*d*) lower cortical layer, but a section across one of the extreme points of a branch shows an approach to a radial arrangement of the above.

The hyphae of the upper cortical layer are welded together so completely that their identity is almost entirely lost, but in the part adjoining the gonidial layer it is possible to trace the cut ends of the hyphae after treatment with potassium hydrate.

The gonidial layer consists of bright green spherical cells interspersed among hyphae that have moderately thin walls. A feature of this layer, especially when there is active growth, is that the gonidia are grouped in spherical masses (fig. 1), a condition that suggests the common origin of each set from a single mother cell. The gonidia composing a group are approximately of the same size, those of one group may have a diameter of three microns while those of another measure as much as ten microns across, but groups of intermediate sizes are always present.

The medullary layer extends through one-half of the thickness of the section; it consists of a loose meshwork of branched hyphae with few septa. The average width of a hypha is four microns.

The mature gonidium of *Evernia prunastri* is a spherical cell with a diameter of from 10 to 15 μ (fig. 3), except when it is subjected to the considerable pressure caused by the rapid multiplication of cells during the periods of active growth (fig. 1). The colourless cell-wall has a thickness of 1·5 μ. The addition of chlorzinc-iodine produces a blue-purple colour reaction but the walls of the hyphae that are present remain colourless. Each gonidium contains a single bright green parietal chloroplast, minutely irregular on the outer surface, surrounding a large central nucleus the diameter of which equals one-third that of the cell (fig. 2). The cytoplasm is finely reticulated; this may account for the statement by a recent writer that a network of hyphae, devoid of a cell wall, sometimes surrounds the chloroplast. One or more minute peripheral bodies stain deeply; they are always surrounded by a light area. The significance of these bodies we have not yet been able to ascertain.

Most writers regard the central body as a pyrenoid but a close examination of it has led to the conclusion that it is the nucleus, for when seen with critical illumination and a magnification of 1000 diameters it appears distinctly granular (7) and when removing superfluous stain (Heidenhain's iron-alum-haematoxylin), by means of the mordant, the colour is reduced

much more slowly in the central body than in the other cell contents. By the fuchsin and bichromate of potash method this body is rendered colourless by thoroughly washing with water after staining; a pyrenoid remains coloured. The central body has not the distinctly semi-crystalline outline so often figured in drawings of gonidia.

It has been generally assumed that the green gonidium of lichens, similar to that of *Evernia prunastri*, increases in number by means of a vegetative cell-division like that observed in the cells of *Protococcus viridis* Ag. (= *Pleurococcus* of most modern authors), viz. by the formation of a transverse wall, and that sporulation takes place only after the gonidium has been isolated from the lichen thallus and subjected to cultural methods similar to those described by Famintzin, and Baranetzky (5), Woronin (13), Bornet (2) and recently by Chodat (3).

The gonidium of *Evernia prunastri* is common to a large number of fruticose, foliose and crustose lichens belonging to the following genera. *Chaenotheca, Calicium, Cyphelium, Sphaerophorus, Candelaria, Parmelia, Cetraria, Evernia, Ramalina, Usnea, Alectoria, Thelochistes, Xanthoria, Placodium, Candelariella, Physcia, Rinodina, Lecanora, Acarospora, Lecania, Icmadophilus, Haematoma, Pertusaria, Gyrophora, Stereocaulon, Cladonia, Lecidea, Biatorella* and *Buellia.*

The gonidium does not multiply vegetatively as a constituent of the lichen thallus, but the original protoplast of the mother cell divides into two, four, eight or sixteen, sometimes more, distinctly separate wall-less masses (figs. 3 and 4). Each of these masses (reduced zoogonidia?) rapidly secretes a cell-wall, develops a chloroplast and nucleus and, in a short period, resembles exactly, in miniature, the mother cell as it appeared before it commenced to sporulate. The mother cell-wall, either by becoming diffluent or by bursting, sets free the daughter cells (fig. 5). May not the empty cells of Danilov (4) or the nekral layer of Elenkin be the empty cells after sporulation has been completed? In most cases the mother cell-wall becomes diffluent and the daughter cells are left together in a spherical group until hyphae force themselves between the daughter gonidia and push them farther apart (fig. 6), or, until they completely surround a group and bind the cells together into a mulberry-like mass.

It is probable that the most active period of sporulation in lowland districts is in the early months of the year, February to April, but sporulation has been found taking place at all periods of the year except during prolonged drought.

Sporulation of the gonidia of *E. prunastri* is exactly similar to that which takes place in *Chlorella vulgaris* Beijer. when

living in a free state. The photomicrograph, fig. 5, is very like that of the drawings by Grintzesco, which illustrate the paper on *Chlorella vulgaris*, with the exception that the chloroplast of the daughter cell in the drawings is decidedly clear at one spot (6). It is not so in the illustration in West, p. 194 (12). The latter adds in his description of the division of the free *Chlorella* cell "It is almost exactly like the formation of zoogonidia in so many of the *Protococcales* and it is not unlikely that the daughter cells are reduced zoogonidia." The same may be said of the formation of daughter gonidia within the lichen thallus.

Diagrams and drawings hitherto published for the purpose of illustrating a transverse section of a lichen thallus containing bright green gonidia convey the idea that the cells are at all periods approximately of the same size even when they are described as cells of *Protococcus* which divide vegetatively by the formation of a transverse wall along which segmentation takes place. The actual separation of the two daughter gonidia is not indicated. There are very few published drawings that suggest sporulation, and when such a suggestion does appear, as in two of the illustrations by Schwendener (9) no description of this condition of the cell is given. The statement is made that the cells are dividing and this has been interpreted as meaning in all cases, dividing vegetatively. The partition wall (eine zarte Scheidewand) is specially referred to. De Bary, 1884, 16 years after the publication of Schwendener's classical paper (8) says "The Fungus alone produces spores, the Alga with a few exceptions remains barren *as long as it is combined with the Fungus*." The only exception that de Bary notes is that of *Synalissa symphorea*, a lichen with a blue-green alga (1). This form of gonidium is not under discussion in the present paper.

The algae *Cystococcus* and *Protococcus* are described as the gonidia of lichens, the first by Schwendener (8) and the second by Bornet (2), but great uncertainty concerning the identity of these has arisen from the fact that in neither case is a detailed account given of the gonidium. The transverse partition of the gonidium, shown in a few of Schwendener's drawings, does resemble a vegetative division, and was regarded as such by the author (10), but in the light of our present knowledge the so-called transverse walls may be the first indication of the splitting up of the protoplast that occurs at the commencement of sporulation. In Pl. VIII, fig. 10 of Schwendener's paper (9) there is a gonidium showing three internal masses out of four that are present; they are similar in shape and arrangement to those now shown in the sporulating gonidium of *E. prunastri*, fig. 3. In both cases three of the tetrahedrally arranged masses

of the divided protoplast are clearly indicated, but in the latter case there is no cell-wall between the masses.

Bornet (2) in his illustrations of the synthetic building of the thallus of *Physcia* (*Xanthoria*) *parietina* from the germinating fungus spores of that lichen and the cells of *Protococcus* leaves one in doubt respecting the identity of the alga. On Pl. X, fig. 2 there are a few cells that indicate division by transverse walls; this suggests *Protococcus viridis* Ag. but great uncertainty on this point arises when it is known that the gonidium of *Physcia parietina* within the thallus, and when isolated, does not divide by a transverse wall but that sporulation takes place similar to that described respecting *E. prunastri*. The question must arise as to whether the alga used in the synthetic building of *Physcia parietina* was pure, in the modern sense of the word. When cutting sections of a lichen thallus a few cells dividing vegetatively are often present on the microscope slide; they are stray ones that have settled upon the upper surface together with fungus spores and other foreign matter. It is of great importance that the thallus should be thoroughly washed before commencing to cut sections for examination, for without this precaution erroneous conclusions will most probably be the result.

In a recent paper (7) it was suggested that the gonidium common to many lichens is a species of *Chlorella*, from the fact that the sporulation of the algal cells, within the thallus and also in those cells that have been isolated from it and subjected to cultural methods, is exactly similar to that which takes place in free *Chlorella* cells. The number of daughter cells produced in the green gonidium of the lichen thallus is usually eight or sixteen. In some free species of *Chlorella*, viz. *C. miniata* Kutz. the same numbers occur. Isolated gonidia, from the thallus of *Cladonia pyxidata*, cultivated on agar-glycose, produced as many as 32 daughter gonidia and in one case a zoospore appeared (No. 63 de la Collection Chodat (3)). Gonidia containing eight or sixteen daughter cells frequently occur within the thallus of *Cladonia pyxidata*.

The identification of the green alga which is common to a large number of lichens has presented great difficulties in the past. Opinion has been based upon the assumption that the absence of spore formation in the lichen thallus is owing to the fact that the alga, on becoming a gonidium, is profoundly altered, so that it ceases to produce aplanospores or zoospores or both. As spore formation of the gonidium has now been clearly demonstrated (figs. 2, 5 and 6) the standpoint as to the identification of the alga is completely changed. The weight of evidence is in favour of the alga being a species of *Chlorella*.

The photomicrographs of microscope slides were voluntarily prepared by Mr J. H. Pledge, F.R.M.S., who had at his disposal, by permission of the management, the apparatus of the physical laboratory of the Kodak Company's factory at Harrow. I take this occasion for expressing my grateful thanks to him for the great skill he displayed in this work.

Having had the opportunity of discussing with Miss A. Lorrain Smith some of the matter brought forward in this communication, I thank her for valuable advice and criticism.

NOTE.

Since reading the above paper I have noted that the alga *Protococcus* is the gonidium of the lichens *Dermatocarpon aquaticum* and of *D. miniatum*. It is not so in the case of *D. hepaticum* and *D. cinereum*.

As regards the two former, the gonidium resembles in size, and in its mode of multiplication by binary fission, the free *Protococcus* obtained from the bark of trees, palings, etc.

This alga has not been modified in shape and size to any appreciable extent on becoming the algal constituent of a lichen.

DESCRIPTION OF PLATE I.

Fig. 1. *Evernia prunastri*. Transverse section of the thallus showing gonidia arranged in spherical groups. × 1000.

Fig. 2. *E. prunastri*. Normal gonidia showing variation in size of the cell according to age. Photograph especially developed to show cell-wall. × 1000.

Fig. 3. *E. prunastri*. Normal and sporulating gonidia. Some are undergoing changes previous to sporulation. × 1000.

Fig. 4. *E. prunastri*. An isolated gonidium containing sixteen daughter-gonidia, not fully developed. × 1000.

Fig. 5. *E. prunastri*. An isolated gonidium containing sixteen fully developed daughter-gonidia. The mother cell-wall has partly disappeared. × 1000.

Fig. 6. *Cladonia digitata*. A group of liberated daughter-gonidia, invaded by hyphae, being forced apart. Two twin-gonidia are on the left. × 1000.

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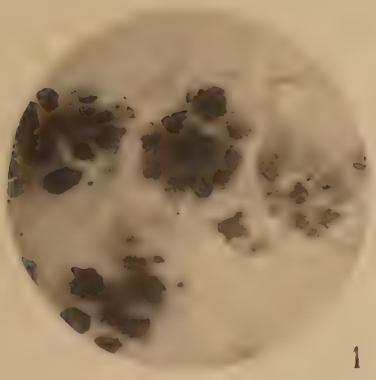

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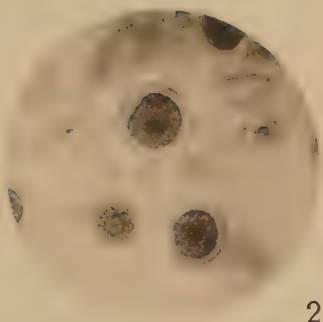

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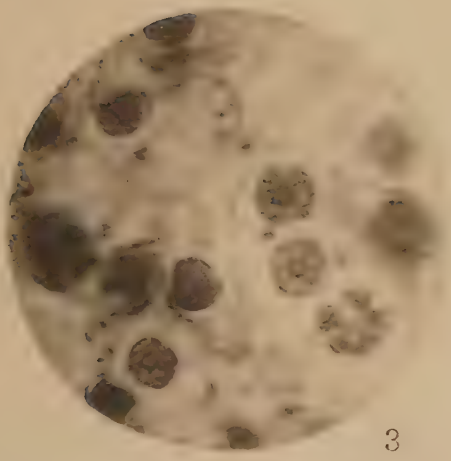

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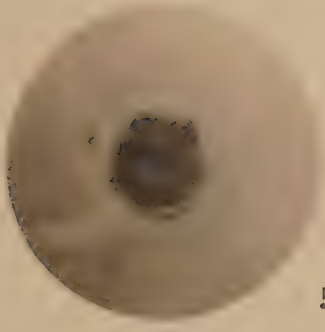

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THREE FUNGI IMPERFECTI.

By Jessie S. Bayliss Elliott, D.Sc., and Helena C. Chance, M.Sc.

Three species of *Fungi Imperfecti* of considerable interest were found growing on some dead twigs of *Pinus sylvestris* picked up in the Oxshott Woods, Surrey, January 1919.

One fungus was somewhat similar to a *Cytospora*, having its sporophores forming a lining layer to the walls of chambered pycnidia: it is allied to *Cytodiplospora*, from which it differs in having bi-septate spores when mature: on this account it must be placed in a new genus which we propose to call Cytotriplospora.

Cytotriplospora, gen. nov.

Stromata erumpentia, pustularia, peridermii laciniis cincta, intus pluri-locellata. Sporulae copiosae, allantoideae, hyalinae, primo continuae, deinde biseptatae, sporophoris longioribus suffultae.

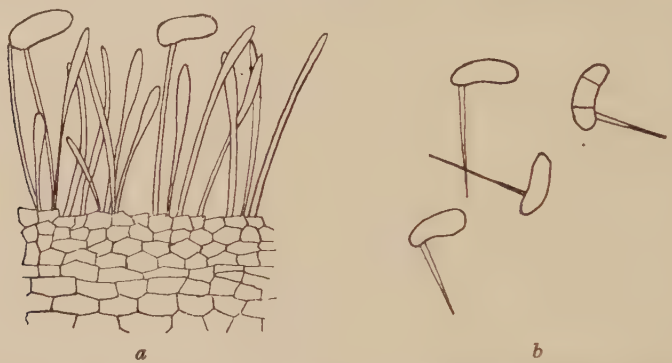
Cytotriplospora Pini, sp. nov.

Pycnidia subconferta, breviter parallele et longitudinaliter seriata, oblonga, 1–6-locellata, atra, 300–500 μ diam., tandem apice erumpentia; sporulae allantoideae, hyalinae, continuae, deinde 1–2-septatae, 15 × 4·5 μ, sporophoris simplicibus, filiformibus, rectis, acutis, circa 1½ quam sporula longioribus suffultae; sporophorae cum sporulis maturis dilabuntur, et tunc spinae vel cilii speciem ostendunt.

Hab. in ramulis *Pini sylvestris*, Oxshott Woods, Surrey.

Pycnidia rather crowded, occurring in irregular lines, somewhat parallel, following the long axis of the twig, oblong,

1–6-chambered, black, 300–500 μ in diameter, at length erumpent at the summit; spores sausage-shaped, hyaline, at first unicellular, at length 1–2-septate, 15 × 4·5 μ; when mature the sporophore breaks away, remaining attached to the spore, and looking like a spine or cilium; sporophores simple, slender, straight, and pointed, about 1½ times the length of the spore.



a *b*

a. Sporophores × 800. *b*. Spore with attached sporophores × 800.

The method of growth of the spores is unusual. They are at first oval, and form a continuation of the axis of the sporophore, then they become cylindrical and curved, and bend over so as to become obliquely attached to the sporophore*.

Spores which bear a great resemblance to these occur in *Pestalozzina Rollandi*, growing on pine leaves, a species which was recorded by Fautrey†. The spine-like structure attached to these spores, Fautrey considered a true cilium, and consequently placed his species in the genus *Pestalozzina*, a genus with ciliate spores. The attached sporophore of *Cytotriplospora Pini* is very much like a cilium and, as Fautrey does not figure the method of growth of the sporophores of *Pestalozzina Rollandi*, it is probable that his so-called "spine" was a sporophore. In this case *Pestalozzina Rollandi* would be a form of this fungus (*Cytotriplospora Pini*) growing on leaves, differing somewhat from the form it assumes on the stem, and should be considered as merely a leaf-form of *Cytotriplospora Pini*. Such a state of things is not unusual in the *Sphaeropsideae*, for there are several species of these fungi which may occur on the stems and leaves of the same plant; when on the stems they have pycnidia, but are without them on the leaves; for instance

* [Mr F. A. Mason has forwarded to me a scale of *Picea excelsa* collected at Reeth, Yorkshire, May 1920, with *Cytotriplospora Pini* on it—identified by Mr W. B. Grove. J. R.]

† See Rabenh. Krypt. Fl. vol. VII, p. 630.

Phomopsis Tulasnei on the stems of the Maple has pycnidia, and *Gloeosporium acerinum*, which is the same fungus growing on the leaves, is without them.

Another fungus proved to be *Naemospora Strobi* Allescher*, which has not hitherto been recorded for the British Isles: this fungus we had also found two months previously growing similarly on *Pinus sylvestris* twigs in Pool Hollies Wood, Sutton Park (Warwick).

NAEMOSPORA STROBI Allesch.

The spores are contained in irregularly shaped cavities more or less fused at maturity, formed under the periderm, the walls having a yellowish tinge; the spores are of two forms, sausage-shaped with a slight depression, 3–4 × 1·5–2 μ, and rod-shaped, 3–4 × 1–2 μ, unicellular, hyaline, numerous; when mature they are exuded in mucus from irregular, somewhat rounded, slits in the bark, and form cream-coloured tendrils; sporophores straight and pointed, fasciculate in bundles of 3–6.

In Allescher's description of this fungus only one kind of spore is mentioned—the rod-shaped, the form which we find only in very mature specimens.

This possession of two kinds of spores, or of spores which assume different shapes, is a common feature in quite a large number of these *Fungi Imperfecti*.

The third fungus was *Fusicoccum bacillare* S. and P., but this specimen differed from that described by Allescher† in having no white disc and larger spores (17–20 × 3 μ); it is interesting as forming a transition between the two varieties *Fusicoccum bacillare* var. *dolosa* and *F. bacillare* var. *acuum*: it resembles the former in having no white disc and the latter in possessing larger spores.

Fusicoccum bacillare grows on the bark of *Pinus sylvestris*, but the variety *acuum* grows on the leaves, so that this fungus, like *Cytotriplospora Pini*, bears out the theory that is now becoming generally accepted, that the same fungus may occur on the stems and leaves of the same plant, and yet have a somewhat different form on the leaf from that on the stem.

We wish to take this opportunity of thanking Mr W. B. Grove for his kind help in the identification of these species.

* See Rabenh. Krypt. Fl. vol. VII, p. 540.
† See Rabenh. Krypt. Fl. vol. VI, p. 550.

TWO NEW BASIDIOMYCETES.

By H. Bourdot.

Among the interesting species which Mr A. A. Pearson has been kind enough to send me, are two which have not yet been described. One of them has been gathered several times in France by M. A. Galzin, and it may be that the species are not very rare; but they are so delicate in substance and disappear so quickly that few observers in the field have paid any attention to them.

One ought perhaps to mention that besides the difficulty of recognising these minute species, there must be considerable hesitation in recording them as new. The reason for this is that certain Basidiomycetes are fertile at a very early or larval stage when they present a very different appearance from the fully developed plant.

Corticium rubropallens (Schw.), *C. lividum* Pers. etc. form at first a pruinose film barely visible; the basidia which are already fertile grow in tufts on the few mycelial hyphae that are scattered over the substratum. In the case of such species, the microscopic characters are practically the same as in the adult stage, and usually one is given a clue to their identity by parts of the sporophore which, especially towards the centre, are more developed and more normal.

In other cases, *Stereum purpureum* Pers., *S. Karstenii* Bres., *Coniophorella olivacea* (Fr.) Karst., the early form is more distinct, and the cystidia especially are so profoundly modified that identification is only possible if one follows for some time the development of the fungus. Some Stereums may start in two ways: in the form of tubercules, small discs or patches with well-defined edges; or in a diffused form, which remains for some time hypochnoid or corticioid. This last mode of development is fairly frequent in *Stereum purpureum*, and one can easily observe it on trunks or branches of poplar which remain some years on the ground, or in the timber yard. Towards the end of the summer the fungus forms a rather light pruinose film, which is already fertile and gradually acquires first a pellicular then a membranous, pale yellow hymenium. The microscopic structure is then almost exactly that of *Peniophora sublaevis* Bres. and at this stage of development the vesiculose cystidia characteristic of *Stereum purpureum* are either completely absent, or very rare. There are, however, numerous hymenial cystidia which are slenderly fusiform, of the same

diameter as the basidia and projecting 25 to 30 μ. After some months growth, the fungus may, by the joining up of several patches, cover a wide area; then the central part becomes atrophied and finally disappears while the peripheral parts, on the contrary, thicken, acquire a purple tint, and tend to turn up at the edges which become covered with hairs; the hymenial fusiform cystidia are replaced gradually by vesiculose cystidia which rise from the sub-hymenial region.

On the other hand there are species with such a tenuous poorly developed appearance that they would be taken either for stunted specimens or for the early stages of more robust forms analogous to those mentioned above. They are, however, fully developed and will always be found in this form. The best instance is *Peniophora accedens* Bourd. et Galz. a small furfuraceous patch of a few millimetres, barely visible to the naked eye, which may easily be taken for dust covering pieces of old wood. We expected to find this plant develop after the manner of *Peniophora glebulosa* or like an *Odontia*, but for fourteen years the gatherings of this minute *Peniophora*, which have numbered hundreds, and have been made in districts widely apart, have never shown greater development, and in all its characters there is such remarkable constancy that one is forced to the conclusion that such forms, until proof to the contrary is brought forward, must be described as autonomous species.

There is much to be done in this part of Mycology which has been for a long time neglected. These examples are enough to show that it is often more important to observe the living plant, than to seek among herbarium specimens for the characters of new species.

The Corticium that Mr Pearson has found was in a luxuriant state of vegetation, occupying the whole of the interior of a pine log rotting on the ground. It was, however, barely visible to the naked eye; it is a ceraceous-pruinose efflorescence, which carpets the narrow interstices which are found between the fibres of wood attacked by *Merulius himantioides* Fr. In the dry state, when looked at with a magnification of about 80 diameters, only a fine network can be observed, fairly regular and made up of white brittle fibres. Its subnavicular spores place it apart from all the ceraceous Corticiums, to which one would compare it. The only species which has microscopic characters approaching it is *Corticium filicinum* Bourdot, but this is a common species in France, which has never varied its habitat on fern débris and from its external characters it is most unlikely that any true

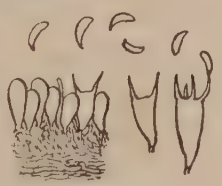


Fig. 1.
Corticium Pearsonii.

relationship can exist between these two plants. I consider *Corticium Pearsonii* as a distinct species which will reappear under the same conditions of habitat and temperature.

CORTICIUM PEARSONII n. sp.

Adnatum, tenuissimum; 20–50 μ crassum, in rimulis ligni cariosi latitans, ceraceo-pruinosum, grisellum, vix continuum, mox furfuraceo-granosum, in sicco lineolis crustaceis albis, eximie reticulatis constans. Hyphae hyalinae, dense intricatae, rarius distinctae; 2–2·5 μ, tenuiter tunicatae, nodulis sparsis; hymenium basidiis et rarioribus hyphis sterilibus, aequilongis compositum; basidia obovata, 9–15 × 5–6 μ, 2–4 sterigmatibus demum arcuatis, usque ad 6 μ longis; sporae hyalinae, anguste clavulatae, lateraliter depressae vel subarcuatae, 4·5–6 × 1·5–2 (–2·5) μ.

In rimulis trunci pinei pullulans, Locus Weybridge, Surrey. Sept. ad finem Octobris 1920; legit A. A. Pearson.

The genus *Heterochaete* Pat. was established for species of *Sebacina* with erect emergences on the hymenium consisting of compacted sterile hyphae with or without cystidia. *Heterochaete dubia*, Bull. Soc. Mycol. Fr. XXV, p. 30 (1909), placed doubtfully in this genus, does not in fact belong to it. This species has no emergences composed of sterile hyphae but only projecting cystidia which brings it into a group of the Sebacineae analogous to *Peniophora*. It is therefore logical to establish a section or sub-genus for the species of *Sebacina* with cystidia, as has been done for the Sebacineae with gloeocystidia.

Fig. 2. *Heterochaetella crystallina.*
1. Spores of the British specimen.
2. Sp. of no. 15208.
3. Sp. of no. 16765.

This new sub-genus Heterochaetella till now only included *H. dubia* with allied forms or species which have not yet been published, and which are distinguished by the spore and nature of the cystidium; in *H. dubia* this is of the same type as in *Peniophora glebulosa* and in other forms, of the type found in *P. subalutacea* or *cineracea*.

The new species, described below, is differentiated from the

others by its cystidium with thin walls, differing however from a gloeocystidium in that the walls are rigid and project a long way. *H. crystallina* comes therefore into *Heterochaetella* for the same reasons that numerous species have been placed in *Peniophora* which have cystidia with thin walls, such as *P. argillacea* Bres., *P. clavigera* Bres., *P. chordalis* v. H. et L., *P. detritica* Bourd. et Galz., étc.

This delicate species has the appearance of a loose thin crystalline film of ice. When older the film collapses, becomes less limpid, and more or less mucous. On drying the fungus contracts, cracks, and is reduced to fine scarious scales, which quickly disappear: when quite dry, there is left on the wood only a slightly polished stain difficult to see. The plant can be made to reappear if herbarium specimens are moistened, but only two or three times at most; after that it becomes absorbed into the pores of the wood. Doubtless such delicate plants might be preserved with advantage in alcohol.

HETEROCHAETELLA nov. subgenus.

Complectens *Sebacinae* species effusas, et genuinis cystidiis praeditas.

H. CRYSTALLINA n. sp.

Pusilla, ½–2 cent. diam. ceraceo-gelatinosa, limpida, setulis hyalinis sub lente hispidula, dein collapso-impressa, tenuissima, indeterminate et interrupte effusa; ambitu similari vel minus continuo, reticulato. Hyphae 0·5–3 μ, ramis hymenium penetrantibus et subinde emergentibus; cystidia tenuiter tunicata, cylindracea, obtusa, sparsa vel passim fasciculata, 60–180 × 7–12 μ, ad 10–45 μ emergentia; basidia obovate vel subglobosa 8–12 × 6–9 μ, longitudinaliter septata, 2–4 sterigmatibus subulatis 5–6 μ dein ad 15 μ longis; sporae hyaline subglobosae vel obovatae, plus minus basi apiculatae, saepe uniguttulatae, (4)–4·5–6 × (3)–4·5 μ, latere germinantes, vel apiculo tunc valde elongato, conico.

Ad ligna putridissima *Pini silvestris* Causse-Noir, Nov. 1914, Galzin, n. 16765; *Juniperi communis* St. Estève, maj. 1914, Galzin, n. 15206–15208, *Aveyron* in Gallia. Ad ligna *Pini silvestris* Horsley, Surrey in Anglia, Nov. 1920, et Feb. 1921, A. A. Pearson.

Further specimens of *H. crystallina* having been gathered in several places by Mr Pearson (always on pine wood in a very advanced stage of decay), it is possible to add some observations on the development and structure of this curious species. In its early stages, it is formed of minute receptacles, 40 to 160 μ in diameter, densely grouped, but distinct. The shape of

the receptacles is very variable, being sometimes hydnoid, sometimes attenuated at the base or substipitate, claviform or obovate, always more or less angular, and sometimes in the form of erect laminae, obovate, and bi-trilobed.

These small fruit bodies have one or more long hyaline hairs projecting at the apex or at the side. In their subsequent development, either by lateral growth or by the intercalation of new tubercles, they become confluent in a net-like manner and finally acquire the form of a continuous pellicle. The plant then, when growing well, is seen as a crystalline pellicle, surrounded by a more or less wide net-work, which resolves itself at the margin into distinct corpuscles. When dry, the reticulate portion resembles a delicate lace thread.

In the most perfect specimen examined, the cystidia are 100–130 × 7–15 μ and project up to 60 μ: they are accompanied by numerous gloeocystidia 3 to 7 μ in diam. which either project slightly or not at all. These gloeocystidia are linked by a series of gradations with the simple or branched paraphyses 1·5–3 μ in diam. or with the fertile hyphae which bear more or less elongated and club-shaped basidia. The hyphae, gloeocystidia and cystidia are bunched together at the base in tufts, as is usual in all species which start with a scattered growth and become confluent subsequently.

In certain parts of the trama, originating in the substratum, are found groups of pyriform vesicles 9–27 × 7–15 μ; these vesicles are not always present, but on the wood near one specimen of *Heterochaetella*, without however touching it, were found small grey pruinose patches which were entirely composed of these tufted vesicles. Is this a distinct species or can one look upon these vesicles as a sclerotic state comparable with *Aegerita candida* Pers. in its relation to *Peniophora aegerita* v. Hoehn. et L.?

NEW BRITISH HYMENOMYCETES.

By A. A. Pearson, F.L.S.

The identification of all the species included in this paper has been confirmed by Monsieur l'Abbé H. Bourdot, to whom I am much indebted. His letters have been freely used in the notes dealing with *Sebacina*. The specific names are used with the significance given to them by Bourdot and Galzin in their papers in the Bull. Soc. Mycol. Fr.

EXIDIA THURETIANA (Lév.) Fr. Hym. Eur. p. 694.

Effused in thick undulating pulvinate or tuberculate patches of a firm gelatinous consistency; opalescent when fresh, sometimes with a pink tinge; hymenium pruinose, finally collapsing into a thin horny yellowish film. Hyphae 1–2½ μ; basidia longitudinally septate 15–20 × 11–15 μ; spores hyaline, cylindrical, curved 15–20 × 5–7 μ. Grows abundantly on the underside of beech sticks lying on the ground.

The large spores and firm consistency are the distinguishing feature of this species.

Horsley, Surrey, Feb. 1920; Painswick, Gloucestershire, May 1920; Worcester, C. Rea, 1920.

SEBACINA Tul.

The species of Sebacina originally described possess a firm crust. The limits of this genus have, however, been extended to include mucous evanescent species.

In Sebacina (sensu stricto) the coriaceous subiculum is sometimes well developed, clavariiform as in *laciniata* Bull., *cristata* Pers., or like a Corticium as in *incrustans* Pers., *sebaceum* Pers. It is now realised that these are all variations of the same species.

But careful observation will show that the above forms, which are summer forms and often almost sterile, are replaced gradually in the autumn and winter by other forms where the coriaceous subiculum is reduced more and more until it disappears. The plant is then spread over the soil or débris and entirely gelatinous-mucous. This form is probably the true *Tremella epigaea* B. et Br. The same plant turned pruinose and bluish by abundant sporulation constitutes *Sebacina caesia* Tul. If growing on wood it might be the same as *S. ambigua* Bres. In all these plants the structure and the spores are the same; only the coriaceous hyphae so abundant on the first forms no longer exist in the last, where, however, the mucous hymenium

remains unchanged. The flat mucous forms are therefore indissolubly linked up with the coriaceous Sebacinas, and there is no point where a division could be made.

SEBACINA FUGACISSIMA Bourd. et Galz. in Bull. Soc. Myc. Fr. XXV, 1909, p. 28.

Effused in a very thin mucous hyaline greyish film, which disappears completely on drying or leaves only a slightly glistening trace barely visible *sub lente*. Hyphae 2–3 μ; basidia longitudinally septate 6–7 × 5–6 μ. Spores hyaline, cylindrical curved 4½–7 × 2½–4 μ.

Horsley, Feb. 1920 and Feb. 1921. On crumbling wood in the last stage of decay.

Since the original description of *Sebacina fugacissima* numerous gatherings have shown the species to be very variable. Some forms are less fugacious than others and the film may vary in thickness, but the structure is the same in all. There is, however, considerable difference in the spore. The commonest is 4½–5 × 3½–4 μ. The type is 6–7 × 2½–3½ μ. Others are 6–7 × 2–2½ and 6 × 4 μ.

There are other closely allied forms with larger spores, to which specific names have been given. It is difficult to define the limits and the value of these forms. The only certain fact is that they constitute a long and almost uninterrupted series.

CORTICIUM SPHAEROSPORUM (R. Maire) v. Höhn. et Litsch. in Sitzungsbericht. K. Akad. Wiss. Wien, CXVII, I, p. 1105, 1908 (= *Hypochnus sphaerosporus* R. Maire).

Thinly effused, arachnoid and porous under the lens, edge indeterminate; chalk white, sometimes with a yellow tinge; hyphae 2–4 μ thin-walled with clamp connections; basidia clavate 9–15 × 4–6 μ with 2 or 4 sterigmata 2–4½ μ long; spores hyaline subglobose or obovate, 1-guttulate, minutely warted with angular warts. 3–6 × 2½–4 μ (mostly 4½ × 4 μ).

Very like *Corticium confine* Bourd. et Galz. in the arachnoid strands covering the hymenium here and there, but easily distinguished by the verrucose spores.

Epping Forest, Oct. 1920 on beech log; Horsley, Feb. 1921 on oak stump.

CORTICIUM SUBMUTABILE v. Höhn. et Litsch. Op. cit. CXVI, 1907, p. 822.

Effused in a very thin pulverulent membrane, pale cream, sometimes with a deeper tint, edge similar; hyphae 1–3 μ thin walled, septate-nodulose, rarely distinct (no clamp connections observed); basidia clavate 8–12 × 4–4½ μ with 2 or 4 straight

sterigmata $2\frac{1}{2}$–3 μ long; spores hyaline, sub-globose, attenuated at base, usually 1-guttulate, rough with short conical warts 3–$3\frac{1}{2} \times 2$–$2\frac{1}{2}$ μ.

On pine stick, Weybridge, Surrey, Sept. 1920.

PENIOPHORA SPHAEROSPORA v. Höhn. et Litsch. Op. cit. CXV, 1906, p. 1600.

Broadly effused, firmly attached to the substratum, 0·15 to 0·30 mm. thick, edge indeterminate, chalk white, smooth or papillate, waxy when fresh, not cracked when dry. Basidia clavate 25–35 × 6–8 μ with 4 long subulate sterigmata. Cystidia abundant, cylindrical, usually narrowed at apex, thin walled, 35–85 × 5–8 μ projecting above the hymenium. Spores globose 4–7 μ diam. apiculate, colourless, smooth, 1-guttulate. Hyphae smooth, thin walled, somewhat nodulose, often anastomosing with frequent clamp connections, 4–5 μ thick.

On fallen stick, probably alder. Weybridge, Nov. 1920, Rev. J. P. Alexander, C.J. and A. A. P.

PENIOPHORA LAEVIS (Fr.) Burt

Broadly effused, membranous, not closely adnate, at first white, then cream, more or less cracked when dry, edge radiately fibrillose; hyphae regular with few or no clamp connections, walls thin, the sub-hymenial hyphae 3–4 μ diam. basal hyphae up to 7 or 8 μ; cystidia fusoid 40–90 × 4–7 μ with or without incrustation (6–11 μ) walls thin or slightly thickened; basidia very variable, 20–36 × 3–7 μ (most frequently 35 × $4\frac{1}{2}$ μ) with 2 or 4 sterigmata 4–6 μ long; spores elliptical oblong, $4\frac{1}{2}$–6 × $2\frac{1}{2}$–$3\frac{1}{2}$ uniguttulate.

On birch bark, Weybridge, Nov. 1920.

HYPOCHNUS ROSEO-GRISEUS Wakef. et Pearson var. LAVANDULACEUS n. v.

Differs from the type in the greyish lavender colour of the hymenium, without trace of pink.

Found in abundance on the ground under *Castanea vesca* at Porlock, Somerset, Sept. 1920.

HYPOCHNUS GRANULOSUS (Peck) Burt. in Ann. Missouri Bot. Gard. III, 1916, p. 218 (= *Grandinia tabacina* Cooke and Ellis); *Zygodesmus granulosus* Peck; *Hypochnus elaeodes* Bresad.

Effused in a thin separable membrane, granular, sepia, margin somewhat radiate, concolorous; hyphae loosely interwoven, thin walled, occasionally nodose-septate, $2\frac{1}{2}$–4 μ diam. yellowish under the microscope; spores same colour as hyphae,

angular, sub-globose, aculeate, the body about 6 μ diam. Burt gives the habitat as rotten bark, and wood of frondose species. In France it is found on sandstone and chalk. The present specimens (Somerset, Sept. 1920 during Minehead foray) were on a pine stick and were rust coloured.

The specific name *tabacina* of Cooke and Ellis, though having priority is not now available as it is already used for Bresadola's species.

MUCRONELLA AGGREGATA Fr. Hym. Eur. p. 629.

Subiculum absent or occasional, teeth subulate, short, free, but arranged in groups, white then pale. Hyphae 2–4 μ with thin walls, clamp connections sparse, basidia cylindrical or clavate 10–20 × $3\frac{1}{2}$–5 μ; spores hyaline elliptical 4–6 × $2\frac{1}{2}$–4 μ.

Under old log in last stage of decay. Horsley, Oct. 1920, A. A. P. and Rev. J. P. Alexander, C.J.

NEW OR RARE BRITISH DISCOMYCETAE.

By Carleton Rea, B.C.L., M.A. etc.

Pustularia lecithina (Cke.) Rea. *Peziza* (*Humaria*) *lechithina* Cke. in Grev. IV, 110. *Helotium lechithinum* Massee, Brit. Fung. Fl. IV, 233.

In September 1920 Mr James Menzies sent me a fine gathering of this species from the neighbourhood of Perth. The hymenium varied in colour from egg-yellow to a deep red orange due to the position of the receptacles, growing either in water on the underside of a stick, or out of the water and exposed to the light. The asci are cylindrical, 250–290 × 15–18 μ, operculate, and do not turn blue with iodine. The spores are hyaline, elliptical, obtuse at both ends, 18–22 × 10–13 μ, 2-guttulate at maturity and accompanied by granulations. The paraphyses are hyaline, filled with large yellow oil drops in the upper portion, gradually enlarged upwards into the clavate apex, 265–300 × 4–8 μ, simple, or branched, septate, contents not turning green with iodine. The hypothecium is pseudoparenchymatous, averaging 50–60 μ in diam. Boudier in his Histoire et Classification des Discomycètes D'Europe, p. 70, doubtfully assigned this species to the Humariaceae, but it is clear from the extended diagnosis set out above that it must be referred to the Pezizaceae and placed in the genus Pustularia.

Ascophanus cervarius (Phill.) Boud. Phill. in Stevenson, Myco. Scot. 308, Brit. Disc. 100.

In August 1920 Mr Norman G. Hadden forwarded to me some specimens of this species growing on Red Deer dung from the Horner Woods, Somerset, and numerous examples were also found there at the autumn foray. The ascophore is quite pallid or whitish at first and it is only with age that it becomes chestnut-brown. The asci are cylindrical, abruptly attenuated at the base, 155–170 × 13–15 μ, operculate, not turning blue with iodine. The spores are hyaline, oblong elliptic, rounded at both ends, 15–17 × 8–9 μ, 1-guttulate. The paraphyses are hyaline, linear, 130–150 × 2 μ, often forked at the apices, septate.

Hyalinia turgidella (Karst.) Boud. Karst. Mon. Pez. 179, as *Peziza turgidella*, Rehm. in Rabh. Krypt. Fl. 1, 3, 680 and figs. 1–5, 651, as *Pezizella turgidella* (Karst.) Sacc.

Ascophores ·2–·4 mm. wide, *white, hyaline, becoming yellowish when dry*, gregarious, or somewhat scattered, waxy, sessile, globose, closed at first and when dry, then cup-shaped, and finally plane and convex, subglabrous or minutely downy. Asci fusiform clavate, 30–40 × 4–6 μ, apex obtusely pointed, inoperculate, foramen immarginate, pore turning slightly blue with iodine. Spores hyaline, oblong fusiform, 5–10 × 1–1·5 μ, with a small oil drop at each end, biseriate or obliquely uniseriate. Paraphyses hyaline, filiform, 35–45 × 1·5–2 μ. Hypothecium pseudoprosenchymatous. On dead grass stems, Perth, 11th July, 1920, Mr James Menzies.

Dasyscypha crystallina (Fuck.) Sacc. Fuck. Symb. Myc. 306. Rehm. in Rabh. Krypt. Fl. 1, 3, 873, as *Lachnum crystallinum* (Fuck.) Rehm.

Ascophore ·3–1 mm. wide, *yellowish white, becoming deeper, or golden yellow with age*, gregarious, waxy, stipitate, globose, closed at first, then cup-shaped; stem ·5–2 mm. long, thin; externally clothed (especially towards the margin) with erect, simple, straight, generally somewhat rough, septate hairs, 40–60 × 3 μ, *gradually enlarged into a clavate or knobbed apex*, 4–5 μ in diam., incurved when dry. Asci cylindric-clavate, 30–40 × 4–5 μ, apex rounded, 8-spored, inoperculate, pore turning blue with iodine. Spores hyaline, oblong fusiform, straight, continuous, 5–8 × 1·5–2 μ, 2-seriate. Paraphyses hyaline, lanceolate, 40–50 × 3–4 μ, often 1-septate towards the base. Numerous crystals of oxalate of lime present in the hymenium and interspersed between the hairs. On dead stems of *Cnicus arvensis* and other herbaceous plants, Perth, 6th June, 1920, Mr James Menzies. Easily known amongst the Dasyscyphae with colourless hairs, by the *knobby apex of the hairs.*

Urceolella deparcula (Karst.) Boud. Karst. Myc. Fenn. I, 150.

In July 1919 and 1920 Mr James Menzies sent me an abundant supply of this beautiful discomycete from the neighbourhood of Perth, growing on the dead stems of *Spiraea ulmaria*. The description of this species given in Massee's British Fungus Flora, IV, 497, as *Belonidium deparculum* Massee, is incorrect, and the one published by Cooke in Grevillia, XX, 38 should be followed as it is a translation of Karsten's original diagnosis. The margin of the receptacle is covered with thin, hyaline, flexuose hairs, 30–40 × 1–1·5 μ at the apex. The asci are *constantly* 4-*spored*, cylindrically clavate, 30–45 × 5–6 μ, not turning blue with iodine. The spores are hyaline; narrowly fusiform, 13–16 × 2 μ, multi-guttulate. The paraphyses are sparse, hyaline, slightly thickened upwards, 25–40 × 1 μ.

Niptera Taxi Rea.

Ascomata ·2–·6 mm. lata, *albida*, ceracea, gregarea vel subsparsa, sessilia, hemisphaerica, dein concaviuscula; margineque crasso, obtuso; substantia concolor, molliuscula. Asci cylindraceo-clavati, apice obtusi, 50–60 × 8–10 μ, octospori, foramine immarginato, apice jodo haud tincti. Sporae hyalinae, leves, ovato-ellipticae, interdum uno latere subcurvatae, 8–12 × 4 μ, *semper primo continuae*, 3–4-*guttulatae*, denique medio septatae, distichae. Paraphyses hyalinae, filiformes, septatae, aequales vel ad apicem clava oblonga, aut globosa, interdum biseptata terminatae, 55–65 × 2–4 μ. Ad corticem truncorum *Taxi baccatae* in societate *Peniophorae laevigatae*, Horsley, Surrey, 2nd May, 1920. Coll. A. A. Pearson. Distinguished amongst the whitish species of Nipterae by the spores constantly 3–4-guttulate from the very first and the habitat on bark of *Taxus baccata*.

Ascocorticium Bref. Bref. Unt. Myk. IX, 145.

Receptacle none, hymenium seated directly on the mycelium, effused, confluent, and *Corticium*-like. Asci small, 8-spored, short, broad, sessile, inoperculate, foramen immarginate. Spores hyaline, oblong ovoid, agglutinated together in an ovoid cluster near the apex of the ascus, and finally ejected together as in *Saccobolus*, but devoid of any surrounding membrane. Paraphyses sparse, cylindrical, slightly shorter than the asci, scarcely enlarged upwards.

Ascocorticium anomalum (Ellis and Harkness) Schroet. *Ascomyces anomalus* Ellis and Harkn. Syn. *Ascocorticium albidium* Bref. in Unt. Myk. IX, 145, see F. S. Earle in Bull. New York Bot. Gard. II (1903), 331.

Greyish white, effused, or in scattered patches, often confluent. Asci sessile, clavate or boot shaped, apex obtusely rounded,

18–22 × 6–8 μ, not turning blue with iodine. Spores hyaline, oblong elliptical, rounded at both ends, 4–6 × 2–2·5 μ, agglutinated together in clusters of eight. Paraphyses hyaline, sparse, narrowly cylindrical or filamentous, 12–16 × 1·5–2 μ. Basal hyphae hyaline, 2–4 μ in diam., sparsely septate. On bark of *Pinus sylvestris*, Weybridge, Surrey, Mr A. A. Pearson, 22nd November, 1920. This is a very interesting addition to the British Fungus Flora, because it represents the Inoperculeae immarginatae group of Discomycetae hitherto unknown in Britain.

UPON THE OCELLUS FUNCTION OF THE SUBSPORANGIAL SWELLING OF PILOBOLUS.

By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.

As is well known, the sporangiophore of Pilobolus shoots away its sporangium to a distance of several feet and therefore acts as a gun. The gun consists of three parts: (1) a basal reservoir which is at first densely filled with protoplasm and which, with the aid of rhizoids, serves to fix the gun firmly to the substratum, (2) a slender cylindrical stipe several millimetres long, and (3) a large oval subsporangial swelling. The shape of the stipe and of the subsporangial swelling is like that of an inverted Florence flask. The projectile—the sporangium—is seated on the free end of the subsporangial swelling, is discoid, is covered with an intensely black membrane, and contains many thousands of spores. *Pilobolus Kleinii* and *P. longipes* can both shoot their largest sporangia vertically upwards to a maximum height just exceeding six feet and to a maximum horizontal distance just exceeding eight feet.

When discharge of a sporangium takes place, the neck of the subsporangial swelling just beneath the sporangium is ruptured transversely, the wall of the swelling and of the stipe contracts elastically, and the cell sap is squirted out of the top of the swelling so that the sap carries the sporangium with it through the air. Hitherto, the swelling has been supposed to function merely as part of a squirting apparatus.

The subsporangial swelling of Pilobolus functions not merely as part of a squirting apparatus *but also as an ocellus* which receives the heliotropic stimulus which causes the stipe to turn the fungus gun toward the light. The swelling is transparent and refracts light like the bulb of a Florence flask filled with water. Its diameter is always greater than that of the black sporangium which it supports.

When the sunlight strikes upon one side of the swelling, the light rays are refracted through it and converge so as to form a spot of light on the other side. When the incident rays of light strike the sporangium head on and are exactly parallel to the long axis of the swelling, the spot of light which is formed by the rays entering that part of the swelling which bulges out beyond and around the sporangium, is symmetrically placed at the base of the swelling. Under these conditions there is physiological equilibrium and no heliotropic reaction takes place. When, however, the incident rays of light strike a swelling obliquely, the spot of light is placed on one side of the wall of the swelling in a manner which is asymmetrical for the swelling as a whole. Under these conditions, the protoplasm which is lighted by the spot of light, sends a heliotropic stimulus down to the protoplasm at the top of the stipe just beneath the base of the swelling. The top of the stipe then reacts by growing in length most rapidly on the side nearest to the spot of light and thus bending as a whole. As a result of this reaction, the swelling is moved about its base through an angle and the spot of light gradually passes downwards on the wall of the swelling until it comes to be symmetrically placed at the base of the swelling. As soon as the spot of light reaches this symmetrical position, a physiological state of equilibrium becomes established in the sporangiophore and the heliotropic reaction ceases. At the end of the turning movement the gun is directed toward the source of the brightest light.

In bright sunlight directed perpendicularly to the long axis of the swelling, the stipe of *Pilobolus longipes* was observed to turn the swelling and the sporangium through an angle of 90°, and thus complete its heliotropic reaction, in about one hour.

In *Pilobolus Kleinii* the protoplasm in the lower part of the subsporangial swelling and at the top of the stipe contains a red pigment; and, at the top of the stipe just above the stipe's motor region, the protoplasm is often heaped up in such a way as to form a strongly bi-concave, very red, centrally perforated septum. As shown by direct observations and by theoretical diagrams, this protoplasmic septum is admirably shaped and situated for receiving the light rays converging upon it when the gun is in a position of complete or almost complete physiological equilibrium. Its concave upper surface, its position with respect to the subsporangial lens, and its strong pigmentation which is especially marked on its upper surface, suggest a comparison in function with the retina of the eyes of certain Mollusca.

The diameters of the sporangium, the subsporangial swelling, and the motor region of the stipe below the swelling in a well-grown *Pilobolus Kleinii* were observed to be 0·43 mm., 0·76 mm.,

and 0·16 mm. respectively. A simple calculation based on these data shows that the sporangium, when head on to a beam of parallel light rays, casts a shadow which has an area 7·2 times that of a cross-section of the stipe. If there were no subsporangial swelling, the shadow of the sporangium would cut off the light from the top of the stipe before the ortho-heliotropic position had been completely attained. This would prevent the gun from being accurately directed toward the source of light. Evidently the difficulty of supplying the stipe with its required delicate heliotropic stimulus has been surmounted in the course of evolution by the intercalation between the sporangium and stipe of the large light-collecting subsporangial swelling. That part of the swelling which bulges out beyond the black sporangium receives the light and concentrates it by refraction upon the base of the swelling, the asymmetrical position of the spot of light so produced providing the stimulus to which the motor region of the stipe can react.

A model for illustrating the Pilobolus gun in its relations with light can be made for demonstrations to an audience as follows. Take a Florence flask, fill it with water, stuff a smooth plug of cotton wool down the neck as far as the base of the neck and then close the mouth of the neck with a cork. To represent the opaque sporangium, stick a plano-convex mass of moulding clay covered with black tissue paper over the flat surface of the flask's base so as just to cover it. As a source of light use direct sunlight or a beam from the arc of a projection lantern.

(1) To imitate the condition of the Pilobolus gun when in a state of physiological equilibrium. Hold the flask in the beam of light with its long axis parallel to the direction of the incident rays and its black base facing the rays. It will now be found that the rays of light falling on that part of the flask's bulb which bulges out beyond the black base are refracted so that they converge within the bulb and brilliantly illuminate the cotton wool plug at the junction of the flask's bulb and neck.

(2) To imitate the condition of the Pilobolus gun when not in a state of physiological equilibrium. Hold the flask in the beam of light with its long axis making a considerable angle with the direction of the incident rays and so that the rays fall obliquely upon the flask's black base. It will now be found that the cotton wool plug is no longer brilliantly illuminated but that a spot of light is formed by the refracted light rays upon the side of the bulb.

(3) To imitate the movement of the spot of light down the side of the subsporangial swelling of the Pilobolus gun when the stipe, responding to a heliotropic stimulus, is turning the subsporangial swelling and sporangium through an angle. Hold the flask as just described, so that the spot of light is upon the

side of the bulb. Now turn the flask so that its axis gradually assumes a direction parallel to that of the incident rays. During this turning movement one can observe that the spot of light gradually moves down the side of the bulb until finally it takes up a perfectly symmetrical position on the cotton wool plug, the plug thus again becoming brilliantly illuminated.

(4) To show that if the cell-sap in the subsporangial swelling were replaced by air, the swelling would not act as a lens. Hold the flask in the beam of light as described in the first experiment. The light is refracted on to the cotton wool plug. Remove the water from the flask without removing the plug. Now hold the flask in the beam of light in the same position as before. The light is no longer refracted on to the plug.

Pilobolus lives in fields, etc., on the dung of herbivorous animals. By directing its guns toward the source of the brightest light, it is enabled to shoot its sporangia into open spaces and, therefore, away from the dung masses and on to grass and other herbage. The sporangia are very adhesive and, especially after they have dried, stick tightly to whatever they have struck. Heavy rain storms do not dislodge them. Herbivorous animals eat grass and sporangia together. The spores pass through the alimentary canal of cattle and horses unharmed and germinate in the solid excreta as soon as they have been dropped.

In the heliotropic reaction of Pilobolus which is caused by the asymmetrical position of a spot of light we have a clear proof of the theory, first suggested by Haberlandt*, that heliotropic reactions may take place in plants through ocellus action.

The sporangiophore of Pilobolus, as far as I am aware, is the only ortho-heliotropic plant organ known which takes up its positively heliotropic position owing to the possession of a special light-perceiving cell structure.

Pilobolus may be well described as a fungus with an optical sense organ or simple eye, and in using its eye for laying its gun, it appears to be unique in the plant world.

The above is an abstract of a paper read December 10, 1920, at Guelph at the second annual meeting of the Canadian Branch of the American Phytopathological Society and again on December 28 at Chicago before the Physiological Section of the Botanical Society of America. On the latter occasion the model described in the abstract was successfully used to demonstrate the lens effect of the subsporangial swelling to a large audience. A fuller description of my observations, accompanied by illustrations, is in preparation for the press.

The University of Manitoba, Winnipeg,
February 1st, 1921.

* G. Haberlandt, Die Lichtsinnesorgane der Laubblätter, Leipzig, 1905.

ON THE LIFE HISTORY AND MORPHOLOGY OF UROCYSTIS CEPULAE

With Plate II.

By T. Whitehead, A.R.C.S.

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Urocystis Cepulae is the cause of a destructive smut disease of onions which has resulted in thousands of acres of land in the United States being rendered unsuitable for the growth of this crop. The existence of the disease in several localities in Great Britain (1) resulting in some years in a total loss of the crop has shown the necessity for taking steps to eradicate this smut, or at least to restrict it to those places where it now occurs.

The present investigation was undertaken concurrently with the laying down of field experiments with a view to opening up new lines of attacking the problem of control. It is mainly concerned, therefore, with those features of the life-history and morphology of the fungus, a knowledge of which would best serve the immediate purpose in hand.

Historical.

In 1889 Thaxter (2) published an account of the history of the disease up to that date, together with a general description of the causal fungus. So far as the writer is aware no further attempt has been made to study the life history of *Urocystis Cepulae* though much has been written on suggested measures of control.

It is desirable to give here a short summary of the history of the disease since Thaxter's paper is inaccessible to most workers in this country. Indeed the present work was well advanced before the writer, through the kindness of Prof. Thaxter was able to obtain his paper. Onion Smut has been known in Connecticut since 1860. It first attracted attention as a serious disease in Massachusetts in 1869–70. About 1876 the fungus was given its present name by Mr C. C. Frost of Brattleborough, Vermont. Previously it was referred to the genus Peronospora. A short account by Farlow appeared in 1876–77 and this was followed in 1889 by Thaxter's paper mentioned above to whom most of our present knowledge of the fungus is due.

Thaxter gives the distribution of the smut as Connecticut, Massachusetts, Ohio, Pennsylvania and possibly several other

Eastern States; the neighbourhood of Paris and Rouen and probably also in the south of France. In Germany it was only known with certainty at Leipzig.

Since 1889 it has spread in the United States as far west as Wisconsin and Iowa; being observed for the first time in the latter state in 1912 (3).

The occurrence of the disease in this country has been described by Cotton (1) who also mentions the fact of its appearance in Denmark.

General appearance of the Disease.

The first indication of the disease is the appearance of one or more elongated, dark patches showing through the translucent outer tissues of the cotyledon when the plant is in second leaf. These opaque patches, indicating the formation of chlamydospores, usually occur just below the "knee" of the cotyledon but occasionally also in the upper part of the leaf. At first the sporogenous mass is embedded in the tissues, but, as the spores mature the mesophyll and epidermis of the cotyledon are ruptured and the spores are exposed as a black fibrous mass in the longitudinal fissure so formed. At the Northumberland centres, where the crop is left unthinned, the death of the plant usually takes place at this stage, but in other localities where onions are grown as an ordinary crop after thinning, successively younger leaves become infected until the plant has developed a bulb of fair size. In those latter cases the crop will usually "grow out" of the disease. Both onions and leeks are susceptible.

The Chlamydospores. The sporogenous mass is composed of immense numbers of chlamydospores which are usually considered to be homologous with the teleutospores of the Uredineae. Each spore consists of one, or very rarely two, central fertile cells surrounded by as many as twenty sterile vesicles or pseudospores; the whole spore ball varying from 15–20 μ in diameter. The fertile cell is from 11–14·5 μ in diameter and its shape, at first globular, usually becomes irregularly polyhedral owing to the pressure exerted by the developing sporogenous mass. It is uninucleated and contains dense granular cytoplasm. The wall is brown in colour, thick (1 μ) and non-laminated. No division into exospore and endospore has been observed nor can germ pores be seen even with the highest magnification (× 2250). The sterile peripheral cells are closely adpressed to the central spore-wall, they are devoid of protoplasm and possess relatively thin walls. The spore ball is extremely resistant to the action of concentrated mineral acids. The vesicles becoming inflated as the acid penetrates the walls indicates the

extreme impermeability of the central spore wall. After prolonged treatment the vesicles separate in the form of round discs.

Viability of Chlamydospores. No useful information based upon observations in this country is available, but in the United States the period during which spores remain viable is often given as at least twenty-five years and in a recent text-book (4) it is stated that there is no evidence of infected land ever becoming clean.

Germination of Chlamydospore. The germination of the spore ball has only been observed under the artificial conditions of the laboratory. In nature we may assume that a resting period after maturation is a necessary preliminary to germination. All attempts by the writer to induce fresh spores from the living leaf to germinate have failed, though Thaxter succeeded in germinating them in onion juice. After drying for about a month the spores were germinated with difficulty by first immersing the leaves in a freezing mixture at $-25°$ C. for twenty-four hours. When, however, spores which had been air dried for some sixteen months were used, germination was effected without the preliminary freezing. The spores were obtained in a surprisingly pure condition from the leaves, but the precaution was adopted of immersing the fissured leaf in 0·1 % mercuric chloride for five minutes and then washing in sterilised distilled water before preparing hanging drops in sterile van Tiegham cells. Occasionally circular or pear-shaped resting spores of an undetermined fungus were present in the hanging drops and a few of them germinated, but they in no way obscured the observations on the germination of Urocystis.

On germinating, one or rarely two germ tubes or promycelia penetrate the spore wall between the sterile cells. Germination in water is slow and the promycelium ceases to grow after attaining a length of some 40–50 μ. Minute ovate sporidia are developed laterally upon the promycelium.

In onion juice, germination is much more rapid and the germinal hyphae are much stouter. They branch and anastomose repeatedly so that under favourable conditions a mycelial plate some 0·25 mm. in radius may be formed in forty-eight hours. Sporidia much larger ($7·4 \times 3·5\ \mu$) than those developed in water are produced laterally and sometimes occur superimposed in pairs. Thaxter states that in none of his cultures did any yeast formation take place as described in other species by Brefeld. In the present investigation, however, a hanging drop which had partially dried up was again flooded with onion juice upon which the sporidia separated from the hyphae and commenced to bud freely. A comparison of figs. 4 and 5 which

show the same germinal hyphae three days and thirteen days respectively after germination indicates that budding may occur whilst the sporidia are still attached to the hyphae. The conditions determining the budding of the sporidia are as yet obscure though one factor is certainly the presence of nutriment in a concentrated form.

It appears probable that budding or yeast formation is abnormal, and may not take place under natural conditions.

Conjugation of sporidia has not been observed.

Germination of Sporidium. The germination of sporidia in water has not been seen, but in onion juice one or rarely two polar germinal tubes were produced which ceased to grow after reaching a length of about 15 μ.

Infection of Host Plant.

It is now firmly established that only seedlings are susceptible to attack; transplants and setts not being affected (5). Thaxter showed that infection is wholly subterranean; a statement which has been repeatedly confirmed by the writer. It is difficult, however, to determine the point at which infection takes place since primary infection and sporulation cannot be demonstrated in the same specimen owing to the early death of the vegetative mycelium. Pot cultures of onions grown in soil contaminated with onion smut showed sporulation invariably within 2 mm. of the collar (i.e. junction of root and cotyledon) and frequently in the collar itself. This observation strongly suggests the collar region as the one at which infection normally takes place. The probability that this is correct is increased by the fact that hyphae indistinguishable from those of *Urocystis cepulae* could be demonstrated in the root hairs in the collars of very young seedlings grown in smutted soil.

Thaxter suggests that since spore masses may occur at the leaf tip infection may be possible also through the cotyledon before appearing above ground. Whilst this is, of course, possible, there is no experimental evidence in support of this view and it should be pointed out that the sporogenous hyphae frequently produce spore masses at intervals in the cotyledon, so that, externally, the dark patches appear to be separated by healthy tissue. It may well be, therefore, that sporulation at the leaf tip is only an extreme case of this discontinuous spore formation.

Method of Infection. The exact method of infection, i.e. whether sporidial or by direct penetration of the promycelium does not appear to have been satisfactorily demonstrated for any species of Urocystis, though Plowright (6) states that he successfully inoculated the leaf of *Ranunculus repens* with the

sporidia of *Urocystis Anemones*. An attempt to determine the relative importance of the sporidial germ tube and promycelium in securing infection was made by the writer in the following way. Young roots severed from healthy seedlings were fixed to coverslips with Canada Balsam. Chlamydospores germinating in water were then sown on the roots and the coverslips inverted over Van Tiegham cells. The promycelia produced by the chlamydospores grew over and amongst the root hairs but in no case were they observed to penetrate the walls. As, however, it proved to be impossible to see whether sporidia were produced on the promycelia, the attempt failed in its main object; only succeeding, in fact, in demonstrating that infection does not invariably occur when a promycelium comes in contact with an onion root.

Growth in Host Plant.

Once inside the host plant the hyphae develop intercellularly at approximately the same rate as the cotyledon grows in length. As in other members of the Ustilagineae the mycelium is evanescent and is difficult to trace far from the region of sporulation. The hyphae are sparsely septate and branching occurs at relatively infrequent intervals. These branches usually turn sharply forward and grow along the longitudinal walls, so producing a mycelium characterised by parallel hyphae. At intervals, which are long in the non-sporulating region and short in the part of the leaf in which sporulation occurs, hyphal branches pass along the end walls of the host cells and anastomose with hyphae growing at a different tangential or radial level. Branched haustoria resembling the intercellular hyphae are produced but do not form a prominent feature of the mycelium. As the spore forming region is approached the hyphae branch much more frequently until a compact mycelium is developed in which individual hyphae are difficult to trace. A pseudoparenchyma, however, is not produced nor is there any gelatinisation of the hyphal walls as described in other species of Urocystis (6).

The sporogenous mycelium is practically confined to the mesophyll lying between the vascular bundles. Only rarely is the phloem invaded and spores have never been found in the outermost layers of the mesophyll or in the epidermis.

Development of Chlamydospore.

The development of the chlamydospore or spore ball is not easy to follow owing to the denseness of the mycelium in which the spores are produced. Most success has been obtained by fixing in Carnoy's fluid young seedlings in which sporulation had just commenced and cutting thick (12–18 μ) longitudinal

sections. The sections are then stained in lacto-phenol-anilin blue and washed out with absolute alcohol until only the hyphae and young spores remain deeply stained.

The first recognisable stage is the formation of a knot of hyphae by the interweaving of short branches from one, or more usually, several neighbouring hyphae. The central hypha swells up at the tip to form the central fertile spore, which at this stage is thin walled and contains a single large nucleus embedded in the dense granular cytoplasm. Gradually the spore wall is thickened and modified into some form of lignocellulose. During the process the surrounding hyphae become adpressed to the spore wall, develop septa at short intervals and round themselves off to form the investing sterile cells. These sterile cells thicken their walls slightly and ultimately lose their protoplasmic contents. The chlamydospores are not formed in any definite order since contiguous spores are often at very different stages of development. The increasing pressure due to this constant production of spores gradually forces the mesophyll cells widely apart and ultimately ruptures the epidermis. The spores fall to the ground and after passing through the necessary resting period germinate and begin the life cycle again.

The writer desires to express his thanks to Prof. Thaxter and to the Connecticut State experimental station for kindly furnishing him with a copy of Prof. Thaxter's paper on *Urocystis Cepulae*.

Summary.

The life history of *Urocystis Cepulae* is relatively simple, chlamydospores giving rise to promycelia which develop sporidia laterally. This observation, originally made by Thaxter, and confirmed by the writer disposes of the view now held that the terminal production of sporidia is a generic character of Urocystis. There is no conjugation of sporidia. Under suitable conditions the sporidia may bud repeatedly though this probably does not take place normally. Infection is in all probability *via* the root hairs in the collar region. There is no interpolation of gonidia in the life cycle as in some genera such as Tuburcinia. The cytology of the fungus has not been studied in the present investigation.

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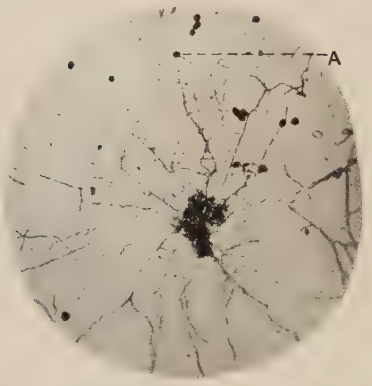

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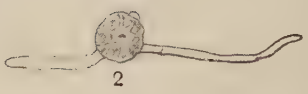

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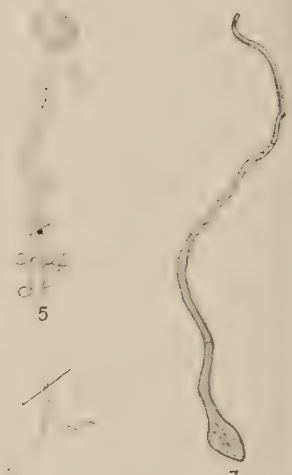

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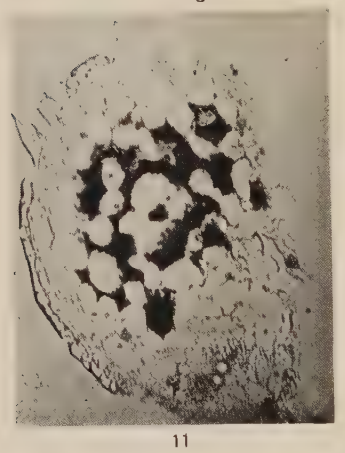

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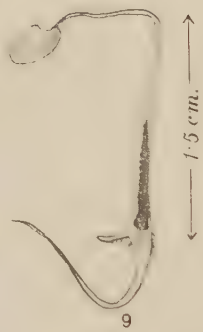

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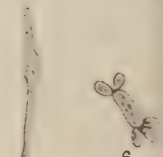

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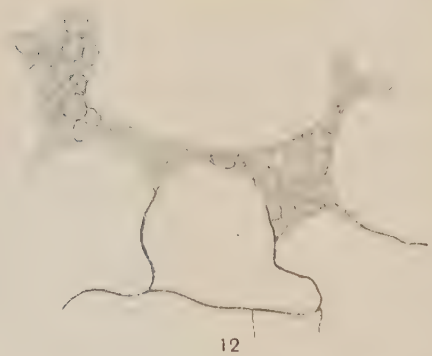

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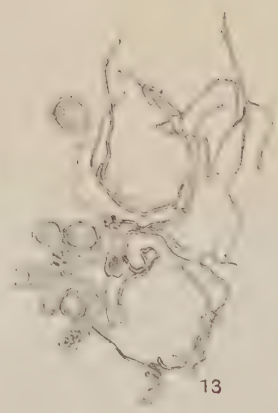

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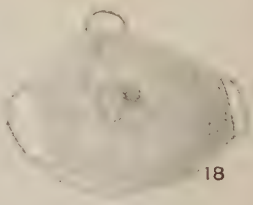

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EXPLANATION OF PLATE II.

Fig. 1. Germinating Chlamydospore. × 400.
Fig. 2. Germinating Chlamydospore, showing two germinal hyphae. × 400.
Fig. 3. Microphotograph of Chlamydospores germinating in onion juice hanging drop. (A) Germinating Chlamydospore shown in detail in figs. 4 and 5.
Fig. 4. Formation of Sporidia (*c*) after 48 hours in onion juice hanging drop. × 400.
Fig. 5. Appearance of same hypha as in fig. 4 after 13 days showing budding of sporidia whilst attached to hypha. × 400.
Fig. 6. Sporidium budding in onion juice hanging drop. × 400.
Fig. 7. Germination of Sporidium, one polar germinal hypha. × 400.
Fig. 8. Germination of Sporidium, two polar germinal hyphae. × 400.
Fig. 9. Young onion seedling showing sporulation in collar.
Fig. 10. Hyphae in root-hair of onion grown in smutted soil.
Fig. 11. Microphotograph of T. S. onion leaf showing distribution of spore masses.
Fig. 12. T. S. onion leaf showing spore masses in intercellular spaces. × 400.
Fig. 13. L. S. onion leaf showing sporogenous hyphae and developing Chlamydospores. × 400.
Fig. 14. Branched haustorium in host cell. × 400.
Fig. 15. Developing Chlamydospore. × 1000.
Fig. 16. Developing Chlamydospore. × 2250.
Fig. 17. Developing Chlamydospore, investing hyphae becoming septate. × 2250.
Fig. 18. Young Chlamydospore showing nucleus and nucleolus. × 2250.

THE INHERITANCE OF DISEASE-RESISTANCE IN PLANTS*.

By F. T. Brooks, M.A.

Soon after the re-discovery of Mendel's law of inheritance in 1901, certain human diseases under suspicion of being transmitted hereditarily, were examined, chiefly from the statistical standpoint, by tracing the incidence of disease in families of known pedigree. In this way it was found that some of these maladies, such as colour-blindness and haemophilia, were transmitted from one generation to another essentially according to Mendel's law, notwithstanding certain complications which can now be explained. It is now known that these particular diseases are sex-linked, the mother transmitting the defect in obvious form to her sons and not to her daughters, in whom the disease is usually either absent or latent.

As regards plants, it has long been clear that some varieties

* Paper read at a meeting of the Association of Economic Biologists, September 1920.

of cultivated plants are much more susceptible to certain diseases than are others. To quote two well-known examples: the variety of potato known as "Up-to-date" is much more liable to attack by blight than is the variety "President," and in wheat "Michigan Bronze" is much more susceptible to yellow rust than is "Squarehead Master." The idea was then conceived by Biffen, that, in the case of certain plant diseases affecting closely related varieties, susceptibility and immunity might be a pair of allelomorphic characters segregating in Mendelian fashion. The work which has been done in this respect in recent years is chiefly due to Biffen and his co-workers. In consequence of their activities it is now clear that, in the broad sense, susceptibility and immunity as regards certain plant diseases can be looked upon as factors which, like many others, are transmissible in an hereditary manner according to known laws.

Much of the evidence at present available in this field concerns the Yellow Rust of wheat, *Puccinia glumarum* form *tritici*, the commonest wheat rust in this country and the one causing most harm in the aggregate.

Biffen (1) crossed certain very susceptible varieties of wheat with other highly resistant ones. The results of one of these crosses, that between the resistant "Rivet" and the susceptible "Red King" will be considered. The hybrid plants resulting from this cross, i.e. the F_1 generation, were found to be all as badly rusted as the susceptible parent. The flowers of these hybrids were then self-pollinated, and, in the resulting generation, roughly one quarter of the plants were highly resistant or immune, while the remainder were moderately or badly attacked by rust. On analogy with other Mendelian results it was most probable that the plants of the F_2 generation showing susceptibility to rust were of a mixed character, those carrying only the factor making for susceptibility to rust, i.e. in Mendelian phraseology, those homozygous to the factor of susceptibility, and those of mixed genetic constitution, the so-called heterozygotes carrying both factors, susceptibility and immunity, the former being dominant or masking the latter. The proof of the genetic constitution of the F_2 plants showing susceptibility to rust would have been shown in the F_3 generation, but unfortunately in this series of experiments the F_3 cultures suffered from various causes and the mortality was so high as to make the results inconclusive in some respects. It was obvious, however, that rust-free F_2 plants produced only rust-free plants in the next generation, and also, that some of the susceptible (F_2) plants gave rise to susceptible F_3 individuals only. There remained, nevertheless, some doubt as to the behaviour of the progeny of the susceptible F_2 plants as a whole, which has since

been cleared up by Armstrong—a co-worker of Biffen, and to whom I am much indebted for kindly allowing me to make use of his results for the purpose of this paper, before they are actually published. Biffen's results showed clearly, however, that resistance to Yellow Rust was inherited as a simple Mendelian recessive character.

Armstrong used the same scale indicating the intensity of rust attack on individual plants as that adopted previously by Biffen. Thus

0	indicated	a rust-free plant.
1	,,	slight attack.
2	,,	moderate attack.
3	,,	bad attack.
4	,,	very severe attack.

Such a scale can only indicate the relative extent of rust attack in a given season. In an exceptionally bad rust year such as 1919, plants placed in grade 3 may be as severely attacked as plants placed in grade 4 another year. It seems, however, to be the only practical method which can be used under field conditions where large numbers of plants have to be examined.

The varieties of wheat chosen for hybridisation by Armstrong were "Wilhelmina" and "American Club," the former being moderately susceptible and the latter highly resistant or immune to Yellow Rust. Both varieties by the way are susceptible to Brown Rust (*Puccinia triticina*) which, however, in Cambridgeshire usually appears on the plants at a much later date than Yellow Rust and does not interfere with observations made on the latter.

In 1916 the cross Wilhelmina ♀ × American Club ♂ was made. About 20 grains were obtained, and in 1917, all the plants arising from these grains were moderately rusted. These F_1 plants were allowed to self-pollinate themselves, and in 1918, of 829 F_2 plants sown in the autumn 627 became rusted, the remainder being rust free. This is a close approximation to the 3 : 1 Mendelian ratio. It should be pointed out that the plants were examined for rust at intervals during the season, the last inspection being made shortly before harvest. The whole F_2 generation—partly sown in the autumn and partly sown in the spring, contained 1560 plants of which 1213 finally were rusted and 347 were rust-free. In the spring-sown portion the proportion of completely rust-free individuals was considerably less than one-fourth of the total number, but on the other hand, the proportion of plants with only traces of rust—to which a special mark (*lx*) was given, was much higher than in the autumn-sown crop. If, in the whole culture, the badly-rusted plants (grades

3 and 4) be separated from those which were less severely attacked, the following totals are obtained:

Bad to severely attacked... ...	381 plants.
Moderately or slightly attacked ...	832 „
Rust-free	347 „

While these figures do not show a very close approximation to the 1 : 2 : 1 Mendelian ratio, the figures expected being 390, 780, and 390 respectively they are suggestive of it, and, as pointed out before, if the autumn-sown plants alone are taken into account, the correspondence is very close.

As regards the F_3 generation, considerations of time and space precluded cultures being raised from all the F_2 plants, so a number of the F_2 plants were selected so as to include individuals showing every degree of attack as well as a number which had remained rust-free. Altogether 198 plants were selected to provide the F_3 cultures. On account of a severe drought during May and June (1919) these F_3 cultures were top-dressed with nitrate of soda as it was feared that some of the plots would be ruined. One result of this application was that, almost without exception, the cultures were more severely rusted than their F_2 parents had been in the previous year. Furthermore, of the 69 cultures which gave evidence of segregation into badly-rusted and slightly-rusted individuals, very few plants remained actually rust-free. In addition, of the 17 cultures raised from F_2 plants which had been free from rust in 1918, in only two cultures did every plant remain absolutely rust-free in 1919. Notwithstanding these results, Armstrong points out that a comparison of these particular cultures with the homozygous susceptible ones growing alongside showed that the relative difference in the extent of rust attack was as great as had existed between their respective F_2 parents in the previous season. Armstrong concludes that, taking all the experimental evidence into account, and more especially the environmental conditions, these cultures were "genetically immune," but that the greater or less degree of predisposition to attack was due to the interaction of other causes or factors.

Of 12 cultures raised from F_2 plants showing only traces of attack, three proved highly resistant and were therefore probably homozygous "immune" cultures; the other nine cultures gave evidence of segregation into slightly, moderately, and badly rusted types, and were clearly the offspring of heterozygous plants.

Sixty-three cultures were raised from F_2 plants which had been moderately attacked. Fourteen of these proved homozygous susceptible cultures, for every plant became badly rusted. The remaining cultures gave evidence that they were the offspring of F_2 heterozygotes.

Of 19 cultures grown from F_2 plants which had been badly rusted in 1918, 15 proved to be homozygous susceptibles, and the others gave evidence of segregation.

The 24 cultures raised from very badly rusted F_2 plants all proved to be homozygous susceptibles.

In this generation, not only did the intensity of attack vary in the different cultures, but also the time of attack. Thus, in general, homozygous susceptibles were attacked earlier than heterozygous susceptibles and the latter were attacked earlier than the "genetically immune" where it happened that the last-named were attacked at all.

Taking the 56 cultures in which segregation in F_3 was clear, it was found that out of a total of 3045 plants, 2385 were either moderately or badly rusted, while 660 were only slightly rusted or not attacked at all. The 3 : 1 Mendelian ratio would be represented by 2284 : 761, and if it exists here, it follows that 101 plants out of a possible 761 recessives were rusted beyond the slight extent indicated by grade 1, i.e. 13·2 %. This degree of "disturbance in rust resistance," as Armstrong calls it, is comparable with that occurring in certain homozygous "immune" cultures of the same series in which 11 % of the plants were rusted beyond grade 1. This disturbance is attributed to the operation of environmental factors previously mentioned.

Seeing that a plant which shows traces of rust attack in one season may be shown by its offspring to have been "genetically immune" and that a rust-free plant in the F_2 generation may be actually an impure susceptible that has escaped infection, Armstrong realised the importance of applying the F_3 results to the statistics of the F_2 generation. In considering the F_2 results in these researches, it was seen that the 1 : 2 : 1 ratio was not closely reached, although it probably existed, as is shown by applying the results of the F_3 cultures to the F_2 statistics. In this way, the probable composition of the autumn-sown F_2 crop was:

202 (homozygous susceptibles) : 419 (heterozygous susceptibles) : 208 (homozygous immunes),

the expected numbers being 207 : 414 : 207.

Similarly, the estimated composition of the spring-sown part of the F_2 generation was 190 : 378 : 163, the expected numbers being 183 : 365 : 183. Taking the whole of the F_2 crop together after adjustment with the F_3 results, the following composition is indicated:

392 homozygous susceptible individuals.
797 heterozygous ,, ,,
371 homozygous immune ,,

These results appear to be conclusive and show that susceptibility and immunity to Yellow Rust can be considered to be genetic factors operating in a Mendelian way.

Resistance to Yellow Rust has thus been shown by Biffen and Armstrong to be a Mendelian recessive character. Resistance to Mildew (*Erysiphe graminis*) as regards wheat has been shown on the other hand by Armstrong to be a dominant character. Thus the variety Wilhelmina, which is very susceptible to mildew, on being crossed by the variety Persian which is immune to mildew, gave hybrids which were also completely immune to this disease. The F_2 generation of this cross grown during 1920 consisted of some 900 plants about 100 of which were attacked by mildew. The rest remained free from attack, but owing to the general weakness of many of the plants, the thinness of the crop, and other conditions unfavourable to mildew attack, Armstrong states that no accurate statistics are available. Further researches therefore are necessary to show how far resistance to mildew can be correlated with the mode of inheritance of resistance to Yellow Rust.

Little work has yet been done concerning the mode of inheritance of resistance to other plant diseases, but there is a wide field of research available here and one full of promise. Indications are to hand that resistance and susceptibility to wart disease of potatoes may be a pair of allelomorphic characters, the practical bearing of which is obvious.

The breeding of disease-resistant varieties of cultivated plants is clearly one of the most effective means of combating plant diseases of economic importance, and this method applied to cereals has already given results of considerable value.

In this connection, however, there are some considerations which must be taken into account, that tend to limit the universal application of the methods of the plant breeder to cure all the ills to which plants are subject. Immunity is a term covering many shades of meaning, and sometimes the so-called immunity to disease is merely the expression of the accidental escape of the host from coming into contact with the germs of the parasite that cause infection. Where immunity is really of the nature of active disease-resistance, the basis of immunity is probably very diverse in different diseases. Thus immunity to a malady such as wart disease of potatoes which is caused by an organism which can only live parasitically, i.e. is an obligate parasite, probably depends upon factors different from those conferring immunity to a wound parasite, where the fungus begins growing as a saprophyte prior to invading tissues consisting perhaps essentially of dead cells. There is as yet no information available as to the inheritance of disease-

resistance in plants affected by wound parasites. As regards plant diseases caused by obligate parasites such as wart disease of potatoes and rust in wheat, it seems necessary to distinguish between what is apparently absolute immunity and what is on the other hand a very high degree of resistance to disease. Now in the case of wart disease some varieties appear to be absolutely immune to this disease, and as far as I am aware, this immunity appears never to have broken down, though it would be hazardous to say that this will not be accomplished under experimental conditions. Rust-resistance in cereals on the other hand does not seem to be absolute in character, but to be influenced in part at any rate by the conditions of environment, including the physiological constitution of the host. Thus, Einkorn wheat, which under ordinary conditions is practically immune to attacks of rust fungi, has been shown by Howard (2) to lose its character of resistance to Black Rust under certain extreme climatic conditions (great heat) at Pusa in India. Again, the variety of wheat "Little Joss," which in the actively growing state is practically free from Yellow Rust during most years is sometimes found to be considerably rusted during the early part of the year. The results given in the earlier part of this paper illustrate the same or an allied phenomenon, for it was often found that plants—described as "genetically immune"—were affected to a slight extent by rust. The offspring of these slightly rusted plants might remain completely rust-free another year, the environmental factor which operated to reduce the resistance during the previous year being thus eliminated. It is clear therefore that although there is an hereditary factor as regards resistance to rust in some wheats, it is not impossible that the conditions of environment have the power of modifying the expression of the genetic factor. There is some evidence too that in wheats of hybrid origin, other factors such as the nature of the root system may themselves influence the general physiological constitution of the plant so as to modify somewhat its powers of resistance to disease. The plant breeder must, therefore, take into account the possibility that changed conditions of environment may break down to some extent the resistance-powers of the host as regards certain diseases, although it is likely that under average conditions of environment, the "genetic immunity" of the resistant variety will be able to hold its own. As is well known, excessive nitrogenous manuring sometimes increases the susceptibility to fungoid disease, and in this connection it is interesting to note that on the Cambridge University farm this year—May and June being very dry, nitrogenous manuring of the highly resistant wheat "American Club" and of the practically immune derivatives of

the cross between this and "Wilhelmina" seemed to have practically no effect as regards rendering them more susceptible to attacks of Yellow Rust. It seems that in these plants the genetic constitution was strong enough to be uninfluenced by a heavy application of nitrogenous manure.

Another consideration to be borne in mind by the plant breeder is that parasitic organisms are themselves plastic and liable to temporary or permanent change leading perhaps to the evolution of races which are more virulent than previous forms. The education of relatively harmless forms of bacteria to pronounced virulence is a well-known phenomenon, and the same may prove to be true of certain fungi, but there is yet little evidence of this. Indeed, evidence obtained by Stakman (3) in America points to the various races of *Puccinia graminis* being very stable forms with little power of adaptability. He has also found that there are several races of *Puccinia graminis* on wheat inhabiting different parts of the United States, so that a wheat resistant in one place is readily attacked at another because it is exposed to infection by another strain of the fungus. Facts of this kind necessarily complicate the problem of breeding disease-resistant varieties.

Notwithstanding these difficulties, which one may perhaps be allowed as a plant pathologist to place before the plant breeder, the latter will probably always be able to keep ahead of important changes in the resistance-power of the host, whether these be due to alterations in its constitution brought about by environmental factors or to increased virulence on the part of the parasite.

It is only in the case of Yellow Rust that we have anything like adequate knowledge of the inheritance of disease-resistance, and even here, we are very much in the dark as to what is the essential factor conferring resistance, although, from the researches of Marshall Ward and others, it is certainly of a subtle, protoplasmic nature. It is suggestive that in some immune wheats the fungus appears to be unable to attack the host with sufficient vigour to establish itself, while in others, the attack appears to be conducted with such violence as to defeat its own ends, the infecting hyphae being surrounded by so many dead host cells that the mycelium cannot penetrate to the living tissues in which alone the quasi-symbiotic life necessary for the rust fungus can be established.

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NOTES ON NEW OR RARE BRITISH FUNGI.

By Malcolm Wilson, D.Sc., F.L.S., F.R.S.E.
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DASYSCYPHA CALYCIFORMIS (Willd.) Rehm.

On the trunk of *Picea excelsa* Link; collected by Dr A. W. Borthwick, Keir, Stirlingshire, March 1914, and by Mr J. M. Murray, near Peebles, December 1920.

This species, which has not been previously recorded in Britain, is a wound parasite causing cankers on the spruce similar to those produced by *D. calycina* Fuck. on the larch; it has also been described on *Abies pectinata* DC., *A. sibirica* Ledeb., *Larix europaea* DC., *Pinus sylvestris* L. and *P. Pumilio* Haenke on the continent. Although often occurring as a saprophyte it has been shown by Wagner (Zeits. f. Pflanzenkrankheiten, Bd. VI, 1896, p. 321) to be parasitic on the silver fir, and Zederbauer (Centralbl. f. d. gesamte Forstwesen, Heft 1, 1906) describes it as causing a serious disease of the spruce in Austria.

It closely resembles *D. subtilissima* Cke. but is distinguished from that species by the following characters:

D. subtilissima, asci 65–70 × 7–8 μ; ascospores slightly curved, 8–10 × 2 μ; paraphyses equal in length to the asci.

D. calyciformis, asci 50–60 × 4·5–5 μ; ascospores elliptic or spindle-shaped, straight, 5–7 × 2·5–3 μ; paraphyses longer than the asci.

The conidial fructifications which have been described by Schellenberg (Mitt. d. Schweiz. Zentralanst. f. d. forstl. Versuchsw. Bd. III, H. 3, 1905, p. 269) were abundant on one of the specimens. The pustules are whitish on the exterior, and are surmounted by the dull yellow mass of conidia; after washing away the conidia they are seen to be slightly cup-shaped with deep tortuous unfoldings of the surface so that in section they appear to be divided into a number of chambers; the conidia are about 3 × 1 μ and are borne terminally on simple conidiophores which form a continuous layer on the inner surface of the fructification. The suggestion made by Hartig (Bot. Centralbl. Bd. 37, p. 78, 1889) that *Phoma abietina* Hart. is the conidial stage of this species was only founded on the juxtaposition of the two fungi and appears to be incorrect.

HYPODERMA PINICOLA Brunch.

On the living leaves of *Pinus sylvestris* L., Glen Lochy, near Dalmally, Argyllshire. Collected by Dr A. W. Borthwick, September 1920.

Fructifications on both surfaces of the leaf, arranged in series, 1–2 mm. long, grey or yellowish-grey, continuously covered by the epidermis, opening by a long slit. Asci club-shaped, very shortly stalked or sessile, 120–170 × 15–20 μ. Spores 8, club-shaped, non-septate, guttulate, thickest at the rounded obtuse upper end and gradually diminishing to the acute lower end, very variable in size often curved, 42–100 × 3–5 μ surrounded by a layer of mucilage 3–5 μ in thickness. Paraphyses filiform, straight or slightly hooked. The fructifications, which may be occasionally more than 2 mm. long, are not at all obvious on the partially dried leaf. They are usually surrounded by an irregular area of brownish- or yellowish-grey dead tissue and the abundance of these areas gives the whole shoot a greyish tinge. The mycelium is abundant in the parenchyma just below the fructifications, but does not extend to the vascular strand and is generally confined to the side of the leaf bearing the fructifications; the hyphae are 3–5 μ in diam., colourless and provided with transverse dividing walls. The covering layer of the fructifications consists of pseudoparenchyma and is 4–6 cells in thickness; the uppermost layer immediately underneath the persistent epidermis is opaque and dark-coloured, the remaining cells having little colouring matter; the whole has a distinct violet tinge. Brunchorst gives no measurement of asci or spores in his description (Nogle norske skovsygdomme. Bergens Museums Aarbog, 1892), but his figure shows that the spores are about $\frac{1}{3}$ the length of the ascus and the length of the spore is about ten times its breadth at the thickest part. The spores in the Scottish specimens are usually longer than this but some agree in shape with Brunchorst's figure. Their size is very variable; generally in each ascus 3–4 spores are about $\frac{2}{3}$ of the length, 2–3 about $\frac{1}{2}$ the length and the remainder only about $\frac{1}{3}$ of the length of the ascus; they are more or less twisted round each other in the ascus. The spores usually escape by an almost transverse rupture towards the lower end of the ascus but sometimes by an apical opening.

Saccardo (Sylloge Fungorum, vol. XI, p. 389) questions whether the species ought not to be placed in the genus *Hypodermella* but the presence of only four spores in the ascus in the latter as well as the considerable resemblance between *Hypoderma pinicola* and *H. nervisequum* seems to negative this.

Lind (Danish Fungi, Copenhagen, 1913) considers that *Hypoderma pinicola* Brunch. is synonymous with *Hypodermella sulcigena* Link. By the courtesy of Prof. Ferdinandsen of Copenhagen it has been possible to examine Danish specimens of the latter species but these unfortunately do not bear ascigerous fructifications. The needles of *Pinus sylvestris* attacked

by *H. sulcigena* bear brownish-black blotches or zones which are considerably larger and darker than the diseased areas produced by *H. pinicola*. The darker colour of the former species is produced partly by the hyphae in the leaf tissue which are up to 6 μ in diameter and pale brown in colour and partly by the brownish discolouration of the leaf tissue, especially the hypoderma. In the description of *H. sulcigena* given by Rostrup (Undersogelser over Snyltesvampes Angreb paa Skovtraerne. P. E. Muller's Tidsskrift for Skovbrug, Bd. VI, 1883, p. 199. Ref. Bot. Centralbt. Bd. XV, 1883, p. 151), the measurements of the asci are given as 75–85 × 12 μ and the ascospores 30–40 × 4 μ; there are only four spores in each ascus. If these measurements are constant there are evidently considerable differences between the two species. In addition the mucilage surrounding the ascospores is stated to stain bright green with tincture of iodine in *H. sulcigena* while this is not the case in *H. pinicola*.

HYPODERMA BRACHYSPORUM (Rostr.), Tub.

On leaves of *Pinus Strobus* var. *nana*, Knight. Murthly, Perthshire, April 1920. Not previously recorded for Britain, but widespread on the continent.

PUCCINIA MILLEFOLII Fuck.

On *Achillea Millefolium* L., Epsom Common, September 1919.

PUCCINIA PAZSCHKEI Dietel.

On *Saxifraga longifolia* Lapeyr., *S. Hostii* Tausch. and its var. *rhaetica* and on *S. Aizoon* Jacq. var. *cultrata*, Royal Botanic Garden, Edinburgh, September 1920.

The sori are usually on the upper surface toward the apex of the leaf, occasionally on the under surface, rounded, up to 3 mm. diam.; a large sorus is often surrounded by a ring of small ones. At first the portion of the leaf around the sorus is yellowish; later on dark brown irregular patches of dead tissue are produced which extend through the thickness of the leaf. Teleutospores 32–38 × 17–20 μ. Previously recorded at Kew on *Saxifraga longifolia*, at Sutton Coldfield on the hybrid *S. Cotyledon* × *S. Aizoon* and in Switzerland and Austria on *S. Hostii*.

PUCCINIA GENTIANAE Link.

Teleutospores on *Gentiana verna* L. and *G. acaulis* L.; collected by Mr D. Hendry, Llanisten, near Cardiff, Oct. 1920.

This species has not been previously recorded on *G. verna* in Britain. Plants of *Gentiana asclepiadea* L. growing in close proximity were not diseased although this species is attacked on

the continent. This species has been previously recorded from Kew Gardens and Horsham.

PUCCINIA SEPTENTRIONALIS Juel.

Since the previous note (Journ. Bot. vol. LIII, 1915) the uredospores of this species have been found on Ben Lui on *Polygonum viviparum* L. and the teleutospores on the same host on Meall nan Ptarmachan; the aecidium on *Thalictrum alpinum* L. has also been collected on Ben Voirlich (Loch Lomond).

PUCCINIA DISPERSA Eriks. et Henn.

Aecidia on *Anchusa arvensis* Bieb. near Kidderminster, August 1912.

Uredospores on *Aira caespitosa* L. Ballinluig, Perthshire, August 1915.

The aecidia on *Anchusa* have been shown to be connected with the form on rye (*P. secalina*). The specimens were found in proximity to a field of rye.

The uredospore stage on *Aira caespitosa* has been recorded from a few localities in England by Grove (The British Rust Fungi, p. 265) but nothing appears to be known of its aecidial host or specialisation. Numerous capitate paraphyses are present among the uredospores.

PUCCINIA MOLINIAE Tul. (?)

Teleutospores on *Molinia caerulea* Moench. near Killin, Perthshire, September 1919.

Teleutospore sori amphigenous, black, elongated, up to 4 mm. long, pulvinate; spores ellipsoid, rounded at both ends, thickened above (up to 7 μ), very slightly constricted, smooth, yellow-brown, 32–44 × 19–29 μ, mostly 36 × 25 μ, pedicels hyaline, persistent up to 160 μ long; mesospores present.

A *Puccinia* on *Molinia caerulea* was collected by Buchanan White in Perthshire, but has not been definitely connected with any aecidium; it appears however to agree in teleutospore characters with *P. Moliniae* Tul.

The present specimens differ from those of Buchanan White principally in the greater thickness of the wall at the apex of the teleutospore. Rostrup (Bot. Tidsskrift, IV, 1874, pp. 10 and 237) in Denmark has shown that *Aecidium Orchidearum* Desm. on *Orchis latifolia* is the aecidial stage of *P. Moliniae* and Schröter has found this aecidium growing along with *P. Moliniae* in Silesia. As a result of Rostrup's work von Tavel (see Klebahn, Die wirtswechselnden Rostpilze, p. 97) has pointed out that *P. Moliniae* should be expected to occur in the plant association found in Switzerland described as "Besenriedwiese" by Stebler and Schröter in which both *Molinia caerulea* and *Orchis sp.*

are found. It is interesting to note that the Killin specimens were found in an association closely resembling this type and this suggests a possible relationship to *Aecidium Orchidearum*. Plowright and others however have been unable to confirm Rostrup's results. Juel (Mykologische Beiträge. III. Ofvers. Kongl. Vet.-Akad. Förh. No. 9, 1894, p. 503) in Norway has proved the connection of a *Puccinia* on *Molinia caerulea* with an aecidium on *Melampyrum pratense* and has given the name *P. nemoralis* to the species; in this the teleutospore wall is somewhat thinner than in *P. Moliniae* Tul. No aecidium on *Melampyrum* has been found in Britain.

Cruchet (Centralbl. f. Bakt. Bd. 17, Abt. II, 1906, p. 674) has described the species *P. Brunellarum-Moliniae* with its aecidial stage on *Brunella vulgaris* (*Aecidium Prunellae* Wint.) and in this species the wall at the apex of the teleutospore is thicker than that of *P. Moliniae* Tul. The specimens may therefore belong to this species and this suggestion is strengthened by the fact that *Aecidium Prunellae* has been recorded from Forres by Keith.

Cruchet considers that the three forms (*P. Moliniae* Tul., *P. nemoralis* Juel and *P. Brunellarum-Moliniae* Cruchet) can be distinguished by curves constructed from the teleutospore measurements, but the use of this method gave no definite indication as to the identity of the specimens. It is hoped to obtain more information on this point during the coming summer.

PUCCINIA ANTHOXANTHI Fuck.

On *Anthoxanthum odoratum* L., Meall nan Ptarmachan, Perthshire at altitudes between 2500–3000 feet, October 1919.

Only uredospores are present accompanied by numerous paraphyses. The sori are exclusively epiphyllous, rather larger and more conspicuous than usual, bright orange-yellow in colour, and seated upon rather conspicuous orange-yellow spots. Uredospores 25–28 μ.

Specimens with the usual characters, with uredospores and paraphyses have also been collected at Ballinluig, Perthshire, and on Mumbles Head, Glamorgan.

CRONARTIUM RIBICOLA F. de Waldh.

Aecidial stage on *Pinus monticola* Don, *P. Cembra* L. and *P. Lambertiana* Doug., Murthly, Perthshire, April 1920. This appears to be the first record on *Pinus Lambertiana* in this country.

MELAMPSORELLA CARYOPHYLLACEARUM Schröt.

Uredospore stage on *Stellaria Holostea* L., Ballinluig, Perthshire, April 1915. Only once previously recorded on this host in this country*.

* West Porlock and Horner Woods. Uredineae of West Somerset, by N. G. Hadden. Journ. of Bot. LVIII (1920), p. 39.

HAPALOSPHAERIA DEFORMANS Syd.

On the anthers of *Rubus fruticosus* L. near Aberlady, Haddingtonshire, 1904. Collected by Dr A. W. Borthwick.

This species was first described by Sydow in 1907 (Annales Mycologici, Bd. v, 1907, p. 398) from material collected in Thuringia, Germany, on *Rubus dumetorum*. At first only mycelium in and among the anthers and isolated spores were found and the fungus was accordingly placed in the genus *Paepalopsis* as *P. deformans*.

Later (Diedicke und Sydow, Annales Mycologici, Bd. vi, 1908, p. 301) the examination of additional material showed that the spores were produced in pycnidia and *Hapalosphaeria*, a new genus of the Sphaeropsidales, was constituted for its reception.

The fungus produces a growth on the *Rubus* resembling a witches' broom. The infected flowers are recognisable in the bud by the enlargement of the sepals, the apices of one or more of these being elongated and sharply recurved. Numerous, small, rounded or conical pycnidia are produced in the outer wall of the anther which open on the surface. The pycnidia are light brown in colour, 50–80 μ in diam.; the wall consists of many layers of small thin-walled cells. The spores are hyaline, spherical, smooth, 3–5 μ in diam. and are budded off from elongated conical cells on the inner side of the wall.

The Scottish specimens generally agree in structure with the above account, but no unusual growth was observed on the bush and no mycelium is present between the anthers; hyphae are however present in abundance in the anther walls and cavities.

MELASMIA EMPETRI Magn.

On the stem of *Empetrum nigrum* L., Creag na Caillich near Killin, Perthshire, altitude 1500 ft., Sept. 1919, and Peaks of the Castles, Arran, altitude 2500 ft., May 1920.

In the specimens collected in the autumn the fructifications were unopened and the conidia immature; in those found in the spring the stomata were split longitudinally and the conidia projected slightly as a pinkish mass. Diseased plants are recognisable on account of the abnormally elongated twigs bearing smaller leaves than usual which become yellow early in autumn.

Magnus, who discovered this species in the island of Wollin, Germany (Berichte d. d. bot. Ges. Bd. iv, 1886, p. 104) supposed that it might be the conidial form of a species of *Rhytisma* and expected to find asci developed in over-wintered specimens but was unable to find spores of any kind on diseased plants in the spring.

The specimens from Arran collected in the spring show typical *Melasmia* conidia similar to those described by Magnus and no trace of asci and it is evident that *Melasmia Empetri* has no connection with any species of *Rhytisma*.

There is little doubt that *Rhytisma Empetri* Buchanan White is identical with *Melasmia Empetri* Magn. In the description of White's specimens given by Berkeley and Broome (Annals and Mag. of Nat. Hist. vol. XVII, 1876, p. 129) no mention is made of the spores but the asci are described as straight and immature; these were probably the sporophores. Three specimens of *Rhytisma Empetri* collected by White are preserved in the Kew Herbarium but these are sterile and contain only sporophores of the *Melasmia* type. There is one specimen in the British Museum herbarium collected by D. Hay probably in Perthshire and named apparently by Broome but this contains no asci. Mr D. A. Boyd informs me that he has collected specimens of *R. Empetri* White near Largs, Ayrshire, and also from Creag na Caillich, but has never found asci developed in them. The late Prof. Trail considered that *R. Empetri* White might be the same as *M. Empetri* Magn. (Scot. Nat. vol. II, n.s. 1881–1888, p. 235). Juel, who has recorded *Melasmia Empetri* Magn. in Sweden (Mykologische Beiträge. II. Ofvers. Kongl. Vet.-Akad. Förh. No. 9, 1894, p. 502) points out that it resembles *Rhytisma Empetri* White fairly well in external appearance. Stevenson (Mycologia Scotica) states that *R. Empetri* White is found in the Tay, Dee, and Moray areas and at Inverness, Rannoch, Braemar and N. Wales. White records it as common in Breadalbane, Athole and Rannoch. No further information regarding its occurrence in N. Wales has been found.

Rhytisma Empetri Fr. (*Duplicaria Empetri* Fuck.) is a different species and has not been recorded as British.

Botrytis Douglasii Tub.

On living shoots of *Pseudotsuga Douglasii* Carr., Murthly, Perthshire; on seedlings of *Pseudotsuga Douglasii* Carr. near Forfar, and on seedlings of *Larix leptolepis* Endl. near Edinburgh. Collected by Mr J. M. Murray, October 1920. This has been shown by Behrens to be identical with *Botrytis cinerea* Pers.; it does not appear to have been recorded previously on these hosts in this country.

I wish to record my thanks to Prof. Ferdinandsen of Copenhagen for specimens of *Hypodermella sulcigena* and the Director of the Royal Gardens, Kew, Mr D. A. Boyd, and especially Mr J. Ramsbottom of the British Museum (Natural History) for information regarding several of the above species.

NOTES.

AUDIBILITY OF THE SPORE DISCHARGE IN OTIDEA LEPORINA.

On the visit of the Cryptogamic Society of Scotland to Perth, in September 1920, *Otidea leporina* was found in abundance, and I brought away half-a-dozen mature specimens to Glasgow. They were packed in a box, each one wrapped in paper, and they remained there twenty-four hours.

On opening the box the specimens were placed on the table, and I attended to something else. While thus engaged I heard every now and then a slight hissing sound, but, being busy, paid no attention to it, till looking by chance at the table I saw one of the Otideae puff, and immediately heard a hiss. The hiss was quite distinct, and required no effort to hear it, although I was fully six feet from the plants. Mr Stone's experience as recorded in the Transactions, vol. VI, p. 294, occurred to me, and placing my six specimens in a row I sat for some time watching my miniature field battery at work. First one fired (puffed), followed by the report (hiss), then another carried on, the others following in their turn at intervals of not more than two or three minutes. I noticed as the time passed that the intervals between the puffs increased in length.

What surprised me was the frequency with which they puffed, but as I was preparing for a journey to the south of England I had to put the specimens away without having noted the length of the intervals between the puffs, the length of time they retained the power of puffing, or the extreme distance at which the hiss could be heard. These points, however, will form material for future investigation.

R. B. JOHNSTONE.

CALIFORNIAN BEES.

During the past two years queries have been repeatedly received concerning the identity of what has been variously called "Californian Bees," "Palestine (or Jerusalem) Bees," "Macedonian (or Salonika) Bees," "Mesopotamian Bees," "Belgian Bees," "Egyptian Bees," "Wine Bees," "Water Bees," "Balm of Gilead," etc. This consists of solid, white, semi-translucent lumps usually about the size of peas and looks somewhat like pieces of soaked sago or tapioca. It is cultivated in sugar solution to which syrup is sometimes added and gives rise by fermentation to what is often called "Bee wine." The lumps move in the solution, the

buoyant dancing being due to the copious evolution of gas bubbles from their surfaces. It is probably this movement that has led to their being called "Bees."

The organism is the well-known Ginger-beer plant which was investigated by the late Professor Marshall Ward*. As the lumps move they shed yeast cells all round which increase and form a deposit at the bottom of the containing vessel: the liquid becomes viscous with slimy masses in it. Ward found that two organisms constitute the ginger-beer plant proper—a yeast, *Saccharomyces pyriformis* and a bacterium, *Bacterium vermiforme*: both are necessary for its formation and peculiar action. Other organisms can be grown out of both the lumps and the liquid but these are merely accessory or foreign organisms such as one would expect to find in a sugar solution exposed to the air. Ward reconstituted the ginger-beer plant by bringing together pure cultures of the yeast and the bacterium and showed that the specimens so produced acted like the original material. He regarded the relation between the two species as one of symbiosis. "The Schizomycete is favoured by obtaining some substance or substances directly they leave the sphere of metabolic activity of the yeast-cells; it can benefit by the presence of these substances even apart from the living yeast, though to a less extent.

The yeast, on the other hand, benefits by these substances being removed and destroyed, hence its renewed and continued activity—as evinced by the steady and copious evolution of carbon dioxide for weeks, and the corresponding increase of the yeast-cells by budding—when the symbiosis is established."

The origin of the plant is unknown. Ward obtained a certain amount of evidence showing that "the yeast (*Saccharomyces pyriformis*) is introduced from the grocers' shops attached to the ginger and brown sugar employed in ordinary practice, while the bacterium (*B. vermiforme*) is introduced with the ginger." That there was an "epidemic" similar to the present one about forty years ago is seen from the following note (*Gardeners' Chron.* XXI (1884), p. 542), by the late Mr Worthington G. Smith.

"The Editor of the *Gardeners' Chronicle* has several times been requisitioned by correspondents (mostly anonymous) for a scientific description of the 'Ginger Beer Plant.' The correspondents want to know its botanical name and native country. The writer of this note has also been tormented weekly, almost daily, on the same subject for two or three years. Every one has been asking him for the 'regular Latin or Greek name' of the 'Ginger Beer Plant.'

* The Ginger-Beer Plant, and the Organisms composing it: a Contribution to the Study of Fermentation-Yeasts and Bacteria. Phil. Trans. Roy. Soc. ser. B. CLXXXIII, pp. 125–197 (1893).

"Benevolent old ladies, clergymen and officers of the Blue Ribbon Army have called upon him, or written for a scientific explanation, hoping to make the 'Ginger Beer Plant' a boon for the poor. One person wished to feed paupers with it; another hoped by its means to knock all the publicans on the head; a third to send it in barrels for the army in the Soudan. When such persons have been told it is merely a form of German yeast they have turned away disappointed and disgusted. Something more must evidently be done for this rum shrub, of which I have recently had applications for slips, rooted cuttings, and seeds.... As all the correspondents insist on this 'American plant' being a new species I propose to humour them by calling it *Zingibeerophora spumacephala*."

Prof. Bayley Balfour exhibited the Ginger-beer plant at the Linnean Society in 1887. His statement—"it is said the Ginger-beer Plant was introduced into Britain by soldiers from the Crimea, in 1855"—is very interesting in connection with the modern names all excepting California being associated with our overseas armies, and many of the individual specimens having a story of a soldier connected with them in some way. From W. G. Smith's note quoted above it is apparent that the plant has been known in America for a number of years. It may be that it has commercial possibilities in that country on account of its fermentative properties. One interesting point is that in no case that has come to my notice has the ginger been added to the solution as in former days.

The method usually employed by English villagers for the making of ginger-beer is as follows*: "They make a solution of sugar corresponding roughly to a 10–20 per cent. solution in tap water, in a large open vessel, a little cream of tartar and a few pieces of ginger are then added; some add lemon as well. The pieces of Ginger-beer plant are then placed in the mixture, and the whole allowed to stand for a day or two. Then the liquor is poured off into bottles and corked, and is drunk after two or three days more. Meanwhile more sugar solution is exposed in the original vessel containing the deposit, or 'lees,' and allowed to stand and bottled off as before."

J. RAMSBOTTOM.

* H. M. Ward, *Loc. cit.* p. 129.

STUDIES IN ENTOMOGENOUS FUNGI.

With Plates III—V*.

I. THE NECTRIAE PARASITIC ON SCALE INSECTS.

By T. Petch, B.A., B.Sc.

Among the fungi known to develop on scale insects, the *Nectriae* occupy the first place from the historical point of view, a conidial stage belonging to this group having been described as growing on a coccus in 1848; while during recent years they have become the species most generally employed in the numerous attempts to control scale insects by means of entomogenous fungi. The present account deals with them from the systematic standpoint, and is the outcome of an examination of a number of collections from different countries which have come into my possession during the last fifteen years, as well as of the specimens in the Herbaria of the Royal Botanic Gardens, Kew, and the British Museum (Natural History).

My thanks are due to Mr E. E. Green, the well-known authority on Coccidae, for much of the available material from Ceylon and elsewhere, including part of the specimens examined and described by Parkin; to Mr H. S. Fawcett for material from Florida; Mr F. W. South, for specimens from the West Indies; Dr E. J. Butler, for specimens from India; Mr C. C. Brittlebank, for specimens from Australia; Prof. Ito, for specimens from Japan and Formosa; and Dr C. Spegazzini for specimens from South America.

I must also offer my apologies to the gentlemen named for the delay in dealing with the specimens they had so readily contributed.

Historical.

The earliest record of any fungus of this group on a coccid was made by Desmazières in 1848. Specimens of a conidial fungus, which appeared on scale insects on willows and ash trees in the winter months at Caen (Cadonum), France, had been sent him by one of his correspondents, M. Roberge, and for these he instituted a new genus, *Microcera*, with the species *Microcera coccophila*.

Desmazières' generic description is "*Microcera* Desmaz., nov. gen. Velum externum persistens, membranaceo-floccosum, dein supra in lacinias plures rumpens; receptaculum clavatum, carnosum, e fibris subsimplicibus sporidiiferis formatum; sporidia fusiformia, arcuata."

* The Plates will accompany the continuation of this article in the next Part of the Transactions.

The specific description is "*Microcera coccophila* Desmaz. Minutissima, subcaespitosa, cornuto-conica, simplex, lateritio-rosea, basi membrana tenuissima albida vaginato-connata. Sporidiis paucis hyalinis, elongatis, utrinque acutis. Hab., in Coccis, Hieme."

Desmazières was so struck by the singular formation and habitat of the fungus that he gave a further extended account of it. In this he was somewhat unfortunate, as it is chiefly this amplification which has led to doubt concerning the identity of his species, and to the inclusion in his genus of forms which have only little relation to it. The following details are taken from his account.

The fungus occurs at the margin of the scale. It appears first as a small horn, sometimes cylindric and obtuse, but most often attenuated from the base to a pointed apex. Each scale produces from one to three horns, but it is not rare to find scales from which arise five or six horns, apparently almost recumbent on the stem of the plant and forming a sort of star. The horns arise from a narrow stroma which runs beneath the margin of the scale, and the growth of this stroma inwards towards the centre ultimately forces off the scale and forms a tubercular mass which unites the bases of the horns. The horns are divergent, and scarcely half a millimetre high. Each is at first enveloped in a white sheath, very thin and membranous, which makes it appear flesh-coloured. This sheath is soon pierced at the apex, and the horn emerges in the form of a small cone, of a dark rose colour, generally with an acute apex which is sometimes curved into a hook. In that state, the persistent sheath, at the base of the little fungus, forms, as it were, a closely adherent volva, the margin of which is fringed. The horn appears fleshy, but is composed, like the sheath, entirely of hyaline filaments, almost simple, obscurely septate, very long, and scarcely 2·5 μ broad. The spores occur among these filaments, few in number, but large, hyaline, fusiform, pointed, and arcuate. The longest are about 100 μ long, with a breadth scarcely double that of the filaments. Frequently, several globules, somewhat equally spaced, occupy the central part of the spore, but septa have not been clearly distinguished.

Desmazières summarised as follows: "In the presence of a velum or volva, this minute production has, to some extent, the nature of a phalloid; in its habitat and fibrillose structure it bears some resemblance to the entomogenous Isarias provided with superficial basidia; and, finally, by its texture, its fibrils or filaments, and the shape of its spores, it is allied to the *Tuberculariaceae*, near *Fusarium*, and to the genus *Ditiola* which is provided with a membranous, evanescent covering or velum."

Desmazières' fungus was next described by the Tulasnes, in

Selecta Fungorum Carpologia, vol. I, p. 130, and vol. III, p. 105. They examined Desmazières' specimens, Plantae Crypt. Gallicae, ed. altera, fasc. XXVII, Nos. 1350 and 1750, and, in the approved modern fashion, had obtained specimens from the type locality. With these they correlated specimens from Florence, on *Laurus nobilis*, which exhibited both the conidial and the perithecial stages. The latter had been issued by Rabenhorst in Herbarium Mycologicum (Ser. nova, t. III (1860), Nos. 262 and 269) as *Nectria episphaeria* Tode and *Microcera coccophila* Desm. respectively. The type locality for the perithecial fungus is therefore Florence, not France as usually stated.

The Tulasnes' description may be summarised as follows. The fungus produces beneath the scale a pallid, or pale rose, fleshy stroma, paler and sparingly byssoid at the edge, which emerges and forms a narrow unequal margin round it. From this there arises a simple, thick, obtuse clava, about a line high. There is usually only one clava, rarely several. The apex is more deeply coloured, red, and bears, in a compact mass, curved linear-lanceolate conidia, 65 × 6·5 μ, three to five septate, borne singly on slender conidiophores. The perithecia appear later, at the base of the clava, or on the margin of the stroma, the clavae being wanting or aborted; they are small, globose, obtusely and very shortly papillate, sessile, very smooth, shining red, fleshy and fragile, in groups of three to five, somewhat collapsed when old. The asci are linear-cylindric, 60–80 × 6·5 μ, obtuse, subsessile, eight-spored, thin-walled; paraphyses are lacking (paraphyses vulgo quasi omnino desiderantur); the spores are smooth, muticate, subhyaline, often obliquely monostichous, ovate, straight, 10 × 5 μ, equally medially septate, and somewhat constricted.

It was noted that in Roberge's specimens from Caen several clavae might arise from the edge of the same scale, but in the specimens from Florence the conidial stage was much rarer.

The Tulasnes placed the fungus in their genus *Sphaerostilbe*, as it had a *Nectria* perithecial stage and a Stilboid conidial form. They stated that the Roberge specimens exhibited clavae which exactly resembled the true *Stilbum* of Tode, and added that the clava of *Microcera* imitated exactly *Stilbum flammeum* Berk. (*Atractium flammeum* Berk. and Rav.), in its form and the slenderness of its filaments, which were united by short isthmuses (ladder connections) and separated into a few straight branches. In their earlier note, they say that *Microcera* differs little from *Atractium*.

For the Tulasnes, then, *Microcera* was a *Stilbum* with long curved *Fusarium* spores. They were somewhat scornful of Desmazières' velum and his comparison with the phalloids,

stating that, whatever appearance of a veil there was, was due to a covering of white adpressed mycelium over the basal stroma, and no true volva was present. This immediately suggests a doubt whether they were dealing with the same fungus, for *Microcera* has the structure described by Desmazières, by whatever name one may call it.

There can, however, be no doubt that the *Microcera* of Desmazières is the *Sphaerostilbe* (conidial stage) of the Tulasnes. Yet one is loth to believe that such acute observers could have overlooked a feature which had been so strongly emphasised in a previous description. The probable explanation is that they were misled by Desmazières' unhappy comparison to a phalloid, and sought for a velum, or volva, surrounding the base of the stem of the Stilboid form: this supposition would appear to be supported by their statement that the apparent volva is merely mycelium on the surface of the stroma. But Desmazières' "velum" consists of the outer layer of the erect parallel hyphae which form the synnema; these are adherent to, or form the outer layer of, the stalk, but they do not terminate above in conidiophores, but in a series of teeth just below the head. They constitute a closely adherent sheath divided above into several narrow teeth which sometimes separate into a fringe of hyphae.

The next record of a *Nectria* on scale insects was made by Berkeley and Broome in their Fungi of Ceylon, No. 1028 (1873). They described there a species, as "*Nectria aurantiicola* B. and Br. Peritheciis aurantiacis in stromate erecto sitis; ascis clavatis; sporidiis ellipticis uniseptatis, sporisque fusuloideis (Thwaites, 190). On orange twigs. Ascospores 15 μ long, 7·5 μ wide; conidia fusiform, curved, multiseptate, 90 μ long; others triseptate and strongly curved, 20 μ long. Apparently growing from some Coccus." They gave figures of "a barren plant"; a stilboid synnema, bearing perithecia on the stalk; asci and ascospores; "flocci with fusiform conidia"; and a single long conidium. In 1875, Berkeley and Curtis described *Nectria aglaothele*, which grew on the remains of a coccus on alder in New England.

About 1886, Spegazzini described a new species of *Nectria*, growing on a coccus on fallen leaves from Brazil, as *Nectria coccorum*; and a few years later (1889), another species, on a coccus on living leaves of a *Eugenia*, from the same country, as *Nectria coccogena*. No conidial stage was recorded for either.

In 1886, Ellis and Everhart described *Ophionectria coccicola* from Florida.

The number of conidial forms was increased in 1887 by the description of *Microcera rectispora* Cke. and Mass. This had

been sent by Bailey from Brisbane, Queensland. In the Handbook of Australian Fungi, Cooke gave figures of the conidia. It grew on "Coccus of the orange."

In 1892, Cooke enumerated and briefly described some of the foregoing species in his Vegetable Wasps and Plant Worms. Of *Microcera rectispora* Cke. and Mass., he stated, "In appearance it differs so little from the European species that, apart from the fructification (*sic*), they would be regarded as the same. So much importance has of late years been given to minute differences in spores that new species have become inevitable. In this instance, the spores are quite straight and spindle-shaped, acute at both ends, with about seven septa, and 150–200 × 10 μ." Cooke's figures suggest the conidial stage of *Ophionectria coccicola*.

In the same year, Ellis and Everhart published their North American Pyrenomycetes. In it they included *Sphaerostilbe coccophila* Tul., stating that specimens had been found on *Alnus serrulata* in Pennsylvania. Their description is practically that of Tulasne. They added "the conidial stage (*Microcera coccophila* Desm.) which has been sent from Florida by Dr Martin, and collected in Carolina by Ravenel (F. Am. 286) has stroma arising from various species of bark lice. It is red, obtuse, and about 2 mm. high. The conidia are linear-lanceolate, 5–7 septate, and 56–65 × 5–6 μ, nearly hyaline."

In 1897, Rolfs reported *Sphaerostilbe coccophila* as a parasite of the San José Scale, *Aspidiotus perniciosus*, in Florida, and inaugurated the use of the fungus as a means of combating that pest. From Rolf's figures, it would appear that he had *Sphaerostilbe coccophila*, or a species closely allied, though later workers in Florida have undoubtedly confused two totally distinct forms.

McAlpine, in 1899, included descriptions of *Microcera rectispora* Cke. and Mass. and *Microcera coccophila* Desm. in his Fungus diseases of Citrus trees in Australia. His description of the former is that of Cooke and Massee. There does not appear to have been any but the type collection of this species; McAlpine cites Bailey's gathering, and adds that it was on *Chionaspis citri*. In the same publication, McAlpine described *Fusarium epicoccum*, on Red Scale on Mandarin orange.

In 1901, Nomura published a paper on the Scarlet fungus disease of Scale insects in Japan. As this was written in Japanese, it had been overlooked by later writers until Miyabe and Sawada drew attention to it. Nomura stated that the sporodochia of his species were not stilboid, but irregularly-shaped protuberances of the *Tubercularia* type; and, after comparison with the figures of *Sphaerostilbe coccophila* given by

Rolfs, he came to the conclusion that his species was identical with that from Florida, but that both were distinct from *Sphaerostilbe coccophila* Tul. He named his species *Nectria coccophila*, and gave the dimensions of the ascospores as 15–20 × 5–6 μ. It occurred on *Aspidiotus perniciosus* and *Diaspis pentagona*.

In the same year, Zimmermann published an account of the fungi parasitic on scale insects in Java. He described a *Nectria* with a stilboid synnema, which he named *Nectria coccidophthora*, distinguishing it from *Nectria aurantiicola* B. and Br. by its colour and the form of the synnemata. It occurred on *Mytilaspis* sp. and *Parlatoria zizyphi*. In addition, Zimmermann recorded and figured *Ophionectria coccicola*, and described two other new species, *Lisea Parlatoriae* on *Parlatoria zizyphi*, and *Broomella Ichnaspidis* on *Ichnaspis filiformis*.

In 1902, Hennings instituted a new genus *Tetracrium* for a conidial fungus found in company with scale insects on orange leaves, in Brazil, the species being named *Tetracrium Aurantii*. This specimen was re-examined by von Höhnel in 1911, and found to be identical in structure with the conidial stage of *Ophionectria coccicola*. Von Höhnel also found on the type specimen perithecia which he regarded as belonging to the genus *Puttemansia* Henn.; he named these *Puttemansia Aurantii*, and made corresponding alterations in the nomenclature of the North American species.

In 1903 Hennings described a new species of *Fusarium*, *Fusarium coccidicola*, on a coccid on tea in German East Africa.

In 1904, McAlpine added two new species of *Microcera*, *Microcera tasmaniensis* on *Aspidiotus* on *Eucalyptus*, and *Microcera Mytilaspis* on a scale on *Hymenanthera dentata*, and gave figures of both species.

Parkin, in 1906, published a general account of the fungi parasitic on scale insects, and gave descriptions of a number of forms, collected in Ceylon and elsewhere. He referred the Ceylon Nectrias to *Nectria coccidophthora*, although there was a previous Ceylon record, viz. that of *Nectria aurantiicola*. The chief merit of his paper, as far as the present group is concerned, is that he recognised that there are two quite different conidial forms, appertaining to the *Nectriae*, common on scale insects in the tropics. But he assigned the *Microcera* form to *Fusarium*, and the other to *Microcera*. Parkin also refers to a *Calonectria*, found on *Chionaspis vitis* and *Mytilaspis citricola* in Ceylon.

In 1907, Trabut described *Microcera Parlatoriae*, found on *Parlatoria zizyphi* on orange at Algiers.

In 1908, Fawcett summarised the records of "*Sphaerostilbe coccophila*," and gave details of its structure, in a paper en-

titled "Fungi parasitic on *Aleyrodes Citri*." He also described a new species of "*Microcera*," but did not name it.

In 1909, Saccardo added a new European species of *Microcera*, *M. curta*, from Germany; and, in 1912, Patouillard described *Microcera Tonduzii* from Costa Rica.

Miyabe and Sawada gave an account of the fungi parasitic on scale insects in Formosa in 1913. They referred the common Japanese species to *Sphaerostilbe coccophila*, with considerable doubt. A *Microcera* which belongs to Parkin's second group was named *Microcera Fujikuroi*. *Ophionectria coccicola* was recorded, and a new species, *Ophionectria tetraspora*, was described.

Sawada subsequently (1914) published, in Japanese, a paper on "Some Remarkable Parasitic Fungi on Insects found in Japan." The only species mentioned which is relevant to the present subject is a new species of *Fusarium*, *Fusarium Aspidioti*, on *Aspidiotus perniciosus*.

In 1913, H. and P. Sydow instituted a new genus of *Sphaeriaceae*, *Coccidophthora*, parasitic on scale insects, on a specimen collected by Hara in Japan, the species being named *Coccidophthora variabilis*. In the following year, however, Hara stated that the specimen submitted to Sydow consisted of two fungi, a *Nectria* parasitic on a scale insect, and another ascigerous fungus parasitic on the *Nectria*. Hara named the *Nectria*, *N. variabilis*, and instituted a new genus for the super-parasite, which he named *Philonectria variabilis*.

In 1914, H. and S. Sydow described *Microcera Merrillii* on a scale insect from the Philippines.

Stevenson, in 1917, described a *Tubercularia* on *Lepidosaphes beckii* and *Hemichionaspis minor*, on Citrus in Porto Rico, as *Tubercularia coccicola*.

The species of *Nectriae*, or their probable conidial stages, which have been recorded as occurring on scale insects are:

Sphaerostilbe coccophila (Desm.) Tul. (1861).
Nectria aurantiicola B. and Br. (1873).
Nectria aglaothele B. and C. (1875).
Nectria coccorum Speg. (? 1886).
Nectria coccogena Speg. (1889).
Nectria coccophila Nomura (1901).
Nectria coccidophthora Zimm. (1901).
Nectria variabilis Hara (1914).
Ophionectria coccicola Ellis and Everhart (1886).
Ophionectria tetraspora Miyabe and Sawada (1913).
Puttemansia Aurantii von Höhnel (1911).
Scleroderris gigaspora Massee (1910).
Lisea Parlatoriae Zimm. (1901).
Broomella Ichnaspidis Zimm. (1901).
Microcera coccophila Desm. (1848).
Microcera rectispora Cke. and Mass. (1887).
Microcera tasmaniensis McAlp. (1904).
Microcera Mytilaspis McAlp. (1904).
Microcera Parlatoriae Trabut (1907).
Microcera curta Sacc. (1909).
Microcera Tonduzii Pat. (1912).
Microcera Fujikuroi Miyabe and Sawada (1913).
Microcera Merrillii Syd. (1914).
Microcera sp. Fawcett (1908).
Tetracrium Aurantii P. Henn. (1902).
Fusarium epicoccum McAlp. (1899).
Fusarium coccidicola P. Henn. (1903).
Fusarium Aspidioti Sawada (1914).
Tubercularia coccicola Stevenson (1917).

Of the twenty-nine species enumerated in the foregoing list, only nine are prior to the current century. The idea that fungi might be parasitic on scale insects and not on the plants on which they occurred appears to have spread very slowly, and, where the scale insect was not immediately evident, such species have been described without reference to their real host. Though the list is no doubt still incomplete, an examination of the species of *Nectria, Sphaerostilbe, Fusarium, Atractium* and *Microcera* in Herb. Kew and Herb. British Museum has shown that the following species are parasitic on scale insects.

Nectria diploa B. and C. (1868).
Nectria laeticolor B. and C. (1868).
Nectria subcoccinea Sacc. and Ellis (1882).
Nectria Passeriniana Cooke (1884).
Nectria oidioides Speg., *myrticola* Rehm.
Sphaerostilbe flammea Tul. (1861).
Atractium flammeum Berk. and Rav. (1854).
Fusarium coccinellum (Kalch.) Thuem. (1876).
Microcera pluriseptata Cke. and Massee (1888).

The following new species are described in this account:

Nectria Tuberculariae.
Nectria barbata.
Calonectria coccidophaga.
Podonectria echinata.
Patouillardiella Aleyrodis.
Fusarium Aleyrodis.

MICROCERA.

Desmazières described *Microcera* as clavate, composed of almost simple hyphae, and furnished with an external sheath, which is toothed at the apex. In his note, he stated that the sheath is closely adherent. The spores are fusiform and arcuate.

The Tulasnes overlooked the presence of the sheath, or if they saw it, did not understand that it was Desmazières' velum or volva. They stated that *Microcera* differed little from *Atractium*, and that some specimens matched the true *Stilbum* of Tode. From their remarks, and the inclusion of the fungus in the genus *Sphaerostilbe*, it is clear that they regarded *Microcera* as composed of parallel hyphae, like the usual *Stilbum*.

The fructification of *Microcera*, therefore, is a synnema, with *Fusarium*-like spores.

The generic descriptions of *Microcera* in the various text-books of mycology have carried on Desmazières' statement concerning the velum, but the fungus has been included in the *Tuberculariaceae*, whereas, in its fully-developed form, it belongs to the *Stilbaceae*. In actual practice, however, any fungus with fusarioid spores, which grew on a scale insect, has been assigned to *Microcera*.

One cannot examine many collections of fungi on scale insects from the tropics without noting that there are at least two distinct forms of conidial fungi, which have fusarioid spores. Parkin appears to have been the first to notice that. He de-

scribed the synnema of "*Nectria coccidophthora*" as having a closely adherent sheath, and that of the other form as having a loose sheath. But Parkin assigned the first, which is the true *Microcera*, to *Fusarium*, and called the second, *Microcera*. As he stated, the two forms are readily distinguished by the naked eye.

Sphaerostilbe flammea, *Nectria laeticolor*, *Nectria aurantiicola*, *Nectria subcoccinea*, *Nectria aglaothele*, and *Nectria coccidophthora* have the *Microcera* conidial fructification, and must all be classed as *Sphaerostilbe*. The second type of conidial fructification will be described as *Pseudomicrocera*; the only *Nectria* yet known to have this conidial stage is *Nectria diploa* B. and C.

The following description of *Microcera* has been drawn up principally from the tropical forms. Specimens from temperate countries, although their perithecial stages prove that they are the same species as those of the tropics, are usually so poorly developed that their structure can be ascertained only with considerable difficulty, and they must be regarded as depauperate examples of the tropical species. It is somewhat surprising that Desmazières recognised the real structure of *Microcera* from specimens collected in Europe, but it would appear from his account that he had a series of living specimens in various stages of development.

Fully developed specimens of *Microcera* (Plate III, fig. 1) are up to 2·5 mm. high, distinctly stilboid, with a stout terete stalk and an ovoid, subglobose, or flattened globose head. Smaller specimens may be clavate, expanding gradually upwards into the head (Plate III, fig. 8). The stalk is composed of parallel hyphae, which separate above and form the conidiophores. The latter give off branches repeatedly, at an acute angle, either alternately or unilaterally, the ultimate branches being usually very long. When the head is teased out, it separates into long brush-like pencils, each consisting of an original conidiophore with all its long branches.

The outer layer of the stalk hyphae do not separate to form conidiophores. They are united to one another laterally, and form a sheath, closely adherent to the stalk, which divides into long triangular teeth at the level of the head. The teeth do not recurve, but remain adherent to the head, and it is necessary to tease out the head in order to see them clearly. In small, or young, examples, the teeth extend almost to the apex of the head, but in larger examples they terminate some little distance below, along the side of the head, or even just above its base. Desmazières' account of the growth of the fungus appears to be correct. When the conidia have been dispersed the teeth may

converge, and form a pointed tip at the apex of the stalk (Plate III, fig. 5). In some instances, there are a few erect fascicles of hyphae, arising from the stroma, surrounding the base of the stalk.

The hyphae of the sheath are united here and there by ladder-connections, i.e. short junctions perpendicular to the hyphae (Plate V, fig. 16). These ladder connections are, however, much more common, and more easily found, between the unbranched bases of the conidiophores. They were noted by the Tulasnes.

The head, normally, is ovoid, but frequently it is curved into a hook, or produced into a point often perpendicular to the stalk. The latter form is, in a sense, accidental. The conidia do not fall off, or blow away, but remain united in a mass by some soluble substance. The fungus grows on scale insects attached to branches, as a rule, and consequently is most generally perpendicular to the branch. But as the branch is often erect or oblique, the mass of conidia bends downwards by its own weight, and thus may become perpendicular to the stalk. The occurrence of dozens of synnemata on the same branch, all with their heads curved in the same direction appears most remarkable until the reason is perceived.

The conidia of *Microcera* (Plate V, fig. 10) are typically narrow-cylindric, or fusoid, nearly straight with falcate tips, 60–120 μ long, 5–8 μ diameter, up to eleven septate, the ends subacute, the distal end being rather more obtuse than the proximal. Sometimes they are quite straight, and sometimes slightly and uniformly curved.

The species of *Microcera* on scale insects are orange red and subtranslucent when fresh, and become brownish red, hard, and horny when dry. When placed in water, the head expands and the outer conidia float off. The synnemata generally arise from a very narrow stroma round the scale; this stroma is tomentose, and, if of any considerable thickness, is composed of interwoven hyphae.

In addition to the stilboid form, reduced forms occur in all the known species of *Microcera*. These may be clavate, with a barely recognisable stalk, or quite sessile, flattened pulvinate, circular or oval in plan, usually seated on the narrow stroma at the margin of the scale (Plate III, fig. 2). These sessile forms may occur together with the stilboid form, or a gathering may consist entirely of either kind. The sessile fructifications are composed of closely packed conidiophores, which arise almost directly from the basal stroma; they are surrounded by a sheath similar to that of the stalked forms.

In the forms from temperate countries, the sessile form of

fructification usually predominates, and the stilboid form, if present, is generally small. Desmazières stated that the clava was scarcely 0·5 mm. high. In the specimen, Desmazières, Plantes Cryptogames de France, Ed. II, Ser. I, No. 1350, in Herb. British Museum, the synnemata are clavate, or conical, or flattened pulvinate; the clavate and conical examples are up to 0·6 mm. high, and 0·3 mm. diameter; the flattened pulvinate examples are up to 0·6 mm. diameter. In *Sphaerostilbe flammea*, Ellis, North American Fungi, No. 1333 (issued as *Nectria subcoccinea* Sacc. and Ellis), the synnemata are conical, 0·35 mm. high, 0·25 mm. diameter at the base, or flattened pulvinate, up to 0·5 mm. long, 0·25 mm. broad.

The sheath in the temperate forms differs from that in the tropical examples in that the teeth tend to divide above into separate hyphae. In some instances, however, the sheath forms a thin membrane which persists after the dispersal of the conidia. An example in Erbar. Crittogam. Ital., Ser. II, No. 542, from which all the conidia had disappeared, consisted of a short stalk 0·1 mm. diameter, surmounted by a membranous cup about 0·1 mm. high, no hyphal structure being discernible in the membranous edge.

Another point of difference lies in the relative development of the conidia and the conidiophores. In the tropical forms, conidia are produced abundantly and there do not appear to be any barren conidiophores or paraphyses: the outer part of the head is a mass of conidia. In the temperate forms, on the other hand, conidia are sparingly produced, and very many of the conidiophores appear to be barren. Desmazières noted that the conidia occurred among the filaments and were few in number, and in some pulvinate examples in his specimens, the barren (?) filaments are so numerous towards the exterior, that the fructification has a distinct white margin. The conidia too are less perfectly developed in the temperate examples. *Nectria aurantiicola* in the tropics has conidia with well-defined septa, while in *Microcera coccophila*, the septa tend to be obscure. But the conidia of *Nectria aurantiicola* from Italy, have obscure and irregularly arranged septa.

No criteria have been found by which it would be possible to distinguish with certainty between the *Microcera* stages of the different species of *Sphaerostilbe* parasitic on scale insects. It is necessary to have examples which have developed the perithecial stage.

Of the species which have been described as *Microcera*, *Microcera Parlatoriae* Trabut, *Microcera curta* Sacc., and *Microcera Tonduzii* Pat. are *Fusarium*, *Microcera Fujikuroi* Miyabe and Sawada and *Microcera Merrillii* Syd. are *Pseudomicrocera*.

Microcera tasmaniensis McAlp. and *Microcera Mytilaspis* McAlp. differ generically from *Microcera* and the foregoing species. *Microcera rectispora* Cke. and Massee is *Tetracrium*. *Microcera pluriseptata* Cke. and Massee, which was said to grow on *Calocera*, is on a scale insect, the supposed *Calocera* being the effete *Microcera* synnemata; this species is *Microcera coccophila* Desm.

PSEUDOMICROCERA.

The second type of conidial fructification which is common on scale insects in the tropics occurs on *Lepidosaphes* (*Mytilaspis*), *Aspidiotus*, *Fiorinia*, *Aonidia*, etc. It was named *Microcera Fujikuroi* by Miyabe and Sawada on specimens from Formosa in 1913, and *Microcera Merrillii* by Sydow on specimens from the Philippines in 1914. In Florida, it has generally been assigned to *Microcera coccophila* Desm., and the majority of the specimens distributed from Florida to European herbaria under that name are *Pseudomicrocera*. It is figured as *Microcera coccophila* by Fawcett in Fungi parasitic on *Aleyrodes citri*, fig. 14, and by Parkin as *Microcera* (figs. 62–66). As it is a common fungus, it may be expected to have been named in the earlier days of mycology without reference to its real host, but it has not been found among the species of *Fusarium* in Herb. Kew or Herb. British Museum. The earliest name yet found for it is *Aschersonia Henningsii* Koorders (type specimen in Herb. Berlin examined), described from specimens from Java in 1907.

The mature perithecial stage of this species has been collected in Brazil, Paraguay, Cuba and Ceylon, and immature perithecia have been found in a specimen from Mauritius. These are *Nectria diploa* B. and C.; the type specimen of the latter contains effete *Pseudomicrocera* sporodochia.

It has not been found possible to differentiate between the specimens of *Pseudomicrocera* from different countries, with the exception that specimens from West Africa have much longer spores than the others. For the present, they must all stand as *Pseudomicrocera Henningsii* (Koord.), while the West African form may be known as var. *longispora*. It is probable, however, that when further specimens of the *Nectria* stage have been collected, *Pseudomicrocera Henningsii* will be found to be a collective species.

The fungus (Plate III, figs. 9–12) forms a thin, but compact, stroma, sometimes glabrous and shining, either at one side of the scale, or as a narrow margin all round it. In some cases, e.g. on *Aonidia* (Plate III, fig. 9), the stroma also grows centripetally over the scale. From this stroma there arise conidial fructifications in varying numbers. In a few instances, no stroma

is visible, and the fructifications appear to arise from the margin of the scale. In general, the fructifications lie flat on the host plant, radiating from the scale, but they are frequently directed obliquely upwards. They are seldom, or never, quite erect.

Each conidial fructification (Plate III, fig. 11) consists of an ovoid, subcylindric, or cushion-shaped base, contracted above and below, as a rule, and surmounted by a conical tip. The distinction between the basal portion and the conical tip is usually well-marked, as the two parts differ both in colour and structure. But in some cases the base is reduced to a height of about 0·2 mm. or less, and then only the conical tip is immediately evident (Plate III, fig. 12).

In well-developed examples, the basal part is ovoid, red, minutely rough, pruinose, and opaque, and has the appearance of a red *Nectria*. In general, however, the base is broader than it is long or thick, and may have a breadth of 0·6 mm., with a height of 0·2 mm. Its sides are usually curved, so that it is constricted above and below, but in the form on *Aonidia* (Plate III, figs. 9, 10) there may not be any constriction above, and the fructification then tapers gradually from the point of attachment to the apex. In small examples, the base is often translucent.

The conical tip consists of long, parallel hyphae, united into narrow triangular teeth, or sometimes into a sheet which is almost continuous. These teeth converge at the apex, in general, but they may stand more or less parallel to one another. As a rule, the tip greatly exceeds the base in length. It may be pinkish when fresh, but on old examples, or in herbarium specimens, it is white.

In the majority of specimens the base is composed of interwoven hyphae. These hyphae are irregular, rather closely septate, constricted at the septa, and with strongly inflated segments, or moniliform, consisting of a chain of more or less rounded cells. These cells are usually filled with a red plasma. The stroma from which the fructification arises has the same structure. The hyphae in this case separate under pressure. They have been figured by Miyabe and Sawada for *Microcera Fujikuroi*.

In the larger examples the development of the base has advanced further, and the hyphae are fused together so that the base is parenchymatous. This happens in the common Ceylon form on *Lepidosaphes*, etc., but it is most frequent and most clearly evident in specimens from Florida and the West Indies. In section the base consists of polygonal thick-walled cells, without coloured contents, hyaline in the centre, but reddish, or red-brown, towards the exterior.

Further details of the structure of this conidial fructification are most easily ascertained from these larger examples. Longitudinal sections show the following.

Towards the top of the parenchymatous base, the cells, though still irregular, become more elongated in a longitudinal direction. This is more especially marked in the central portions. From these elongated cells, there arise short conidiophores which form a continuous disc over the upper surface of the parenchymatous base. The marginal cells of the base, however, give rise to long, septate hyphae which are united into fascicles. These fascicles converge above and constitute the conical apex. Viewed from the exterior they are long-triangular: in section they are several hyphae thick at the base, and in some cases there is, at the base of the fascicle, a distinct inner and outer layer of parallel hyphae separated by a layer of parenchymatous tissue which gradually becomes thinner and disappears at a short distance from the base. On the inner side of these fascicles there may be a small number of long, septate hyphae, similar to those which form the fascicles, but free, and constituting "paraphyses."

The structure consequently resembles that of a Discomycete. The parenchymatous base is to some extent differentiated into a "hypothecium" of elongated cells which bear the conidiophores, and an "epithecium" of more isodiametric cells. The long marginal hyphae arise from the uppermost cells of the "epithecium."

This structure is illustrated diagrammatically on Plate V, figs. 20 and 21. Fig. 20 shows the base and the tip viewed from the lower surface, the wall of the tip being shown as continuous. Fig. 21 is a longitudinal section of a well-developed specimen with a parenchymatous base and the teeth on the upper side longer than those on the lower.

The conical tip was designated by Parkin a "loose sheath" in contradistinction to the "closely adherent sheath" of *Microcera* (*Fusarium* of Parkin). But, although it resembles the latter in being composed of long, septate hyphae, which are united by ladder connections, it differs from it in several particulars. It is not a continuation of the outer layer of the base, but differs entirely in structure from the latter. It is composed, at least in the lower part, of several layers of adherent hyphae. It does not sheath the bases of the conidiophores but is a marginal border to a slightly concave disc, and encloses a mass of detached conidia.

In many cases, the hyphae which constitute the segments of the tip are not of the same length all round the disc. It has already been stated that the fructification is rarely erect, but usually horizontal and often oblique. The hyphae of the teeth

on the lower side are often shorter than those on the upper. Consequently, when the fructification is viewed from below, large specimens show an oval opening, through which the orange-coloured disc may be visible. The sporodochium then resembles a small *Otidea*.

The marginal hyphae may be united into a continuous layer surrounding the disc, or divided into teeth or segments to varying depths from the apex. In some forms, this envelope is continuous up to the apex on the upper side, and divided down to the base in the median line on the lower.

The conidiophores are short, as a rule. They are at first unbranched and about 30 μ long, but become branched and about 60 μ long. They resemble the conidiophores of *Microcera* in diameter and branching, but are very considerably shorter. It is possible that they may attain a greater length in some species, but in all the cases observed, the ultimate branches are short, and the conidiophore branched almost from the base. Probably because of the shortness of the conidiophores, ladder connections between them are absent, or at least rare.

The conidia are long, three to five septate with long aseptate tips, and, in the forms examined, are usually regularly curved from tip to tip (Plate V, fig. 17). They remain for some time enclosed within the tip in an orange, or coral-red, mass, the apex of which projects slightly, but, judging from the available specimens, they are more readily dispersed than those of the true *Microcera*.

The structure of this conidial form is evidently quite different from that of the *Microcera* described by Desmazières; and it does not appear to agree with any existing genus. I therefore propose for it a new genus, *Pseudomicrocera*.

Pseudomicrocera. Sporodochium conical; base ovoid, or cylindric, or pulvinate, parenchymatous, or composed of interwoven irregular hyphae, surmounted by a discoid layer of conidiophores with a marginal zone of long hyphae, united into a continuous sheet or into fascicles of varying breadth, which are connivent at the apex; conidiophores branched; conidia elongated, narrow, curved, septate, hyaline.

The following forms of *Pseudomicrocera* have been examined.

A. Specimens on *Aspidiotus* on *Citrus*, Florida, U.S.A. (Plate III, fig. 11), and on *Aspidiotus* and *Ischnaspis filiformis*, on Coffee, Grenada, West Indies.

The sporodochia are oblique or horizontal. The scale at first has a radiating byssoid margin, which develops into a more compact yellowish-white stroma, at the side of, or covering, the scale. The sporodochia may arise from the margin of the scale, or from the stroma. In some cases the sporodochium arises at

the side of the scale from a more or less circular, thin, parenchymatous disc, which separates from the leaf with the sporodochium. The stroma may be floccose or parenchymatous.

The total height of the sporodochium is, as a rule, up to 0·8 mm., but specimens up to 1·5 mm. high occur. The base is subcylindric, but usually broader than high, and somewhat compressed from front to back. Large specimens have a base 0·6 mm. broad, and 0·5 mm. high; in smaller examples, it is about 0·5 mm. broad and 0·3 mm. high. The base is pinkish-red, opaque, with a delicate white pruina, and is usually contracted above and below. The tip is conical, longer than the base, white or pinkish, divided into segments or teeth to varying depths. The teeth are shorter on the lower side of the sporodochium, and, hence, when it is viewed from the lower side, the orange-red disc is visible through an elongated oval opening, more especially in the larger specimens.

In section, the base of the larger specimens is parenchymatous, being composed of polygonal, rather thick-walled cells, 4–6 μ diameter, with a few 10 μ diameter. The exterior cells are smaller than those in the interior and have reddish walls. The hyphae of the tip are 4 μ diameter, equal, septate, united by ladder connections. In large specimens, the teeth are up to 120 μ thick at the base on the upper side, and 60 μ thick in the corresponding position on the lower. The conidiophores are simple, or closely branched, 3 μ diameter, equal, up to 50 μ long in the centre of the disc, longer towards the margin.

The conidia are arcuate, sometimes almost straight with curved tips, generally three-septate, but sometimes four- or five-septate, hyaline; in the Florida specimen they measure 60–70 × 3–5 μ; in the Grenada specimen, 50–66 × 3 μ, measurements made straight from tip to tip. In the latter specimen, the conidia tend to collapse laterally.

This form differs from the common Ceylon form in that the base is more usually parenchymatous, and the conidia, on the average, are shorter.

B. On *Lepidosaphes*, *Aspidiotus*, *Fiorinia*, *Ischnaspis*, from Ceylon, India, Australia, Mauritius, Java, and Formosa (Plate IV, fig. 12).

The stroma is narrow, compact, slightly irregularly pulvinate, tomentose, with a radiating byssoid margin. The marginal hyphae tend to fuse into a membranous hyaline sheet. The stroma may completely surround the scale or be confined to one side. As a rule it does not grow over the scale, but it may completely cover small examples. In some cases, the sporodochia appear to arise direct from the scale, no stroma being visible externally. The sporodochia are horizontal, as a rule.

The base of the sporodochium is pulvinate, pinkish-red, opaque or subtranslucent, tomentose, 0·2 to 0·6 mm. broad, and 0·06 to 0·2 mm. high. The total height of the sporodochium is up to 0·6 mm. The marginal teeth are long, triangular, divided down to the base, usually connivent, either of equal length all round, or shorter on the lower side.

In herbarium specimens the stroma and base of the sporodochium become yellow.

The conidia are arcuate, equally curved, hyaline, three- to five-septate. Measurements from different gatherings have given, 80–100 × 4 μ; 80–90 × 4–4·5 μ; 82–92 × 3–5 μ (Mauritius); 76–94 × 4 μ; 74–92 × 3–4 μ.

I have examined the following collections of this form. On *Fiorinia rubrolineata* on *Murraya exotica*, Ceylon. On *Ischnaspis* sp. on *Funtumia*, Ceylon. On *Lepidosaphes* sp. on orange, Ceylon. On *Mytilaspis pallida* on *Codiaeum variegatum*, Ceylon (Parkin's specimen). On *Aspidiotus* sp. on *Hevea*, Ceylon. On *Fiorinia fioriniae* on *Camellia*, Mauritius (Parkin's specimen). On a diaspid on Tea, Java. On *Aspidiotus* on orange, Jorhat Farm, Assam (E. J. Butler). On scale on *Indigofera*, Bassein, Burma (E. J. Butler). On *Aspidiotus ficus* on *Citrus*, Port Darwin, N.T., Australia.

Specimens of *Microcera Fujikuroi* Miyabe and Sawada from Herb. Sapporo have been kindly lent me by Prof. Ito. One, on *Aspidiotus ficus* Comst. on *Citrus nobilis*, Sensoho, Formosa, October 30, 1906, has stromata either hidden by the scale, or forming a narrow border on one side, or covering the scale except in the centre. The sporodochia are horizontal, spreading stellately from the scale. The base is small, about 0·1 mm. high. The conidia are curved, equally attenuated, usually five-, sometimes six-septate, with long aseptate tips, 72–94 × 3–4 μ; they tend to collapse laterally, like those of the West African form noted below. The hyphae of the teeth are slightly stouter, and have thicker walls, than in specimens from other countries, but in other respects they do not differ from the Ceylon form on *Aspidiotus*.

The type specimen of *Microcera Fujikuroi*, on *Aspidiotus ficus* Comst. on *Citrus nobilis*, Taihoku, Formosa, February 29, 1908, is identical with the foregoing, but poorly developed. From Prof. K. Hara, I have received specimens on *Abies firma*, Shizuka, October, 1918.

A specimen, *ex* Herb. Victoria, on *Aspidiotus ficus* on *Citrus*, Port Darwin, N.T., July 13, 1915, has a narrow, pink, fimbriate stroma round the scale, with the sporodochia lying horizontally on the leaf or emerging from the apex of the scale. The sporodochia are variable, some having an opaque base, 0·1 mm. high,

with a white tip 0·3 mm. high, while others appear wholly translucent, the tip being filled with an orange-yellow mass of conidia. The conidia are of the usual form, or almost straight with curved tips, up to five-septate, 70–90 × 4 μ.

In another Australian gathering, on *Lepidosaphes* sp. on *Melaleuca leucadendron*, Stapleton, N.T., the stroma is dark red, subtranslucent, irregular, either situated at one side of the scale or overgrowing it completely. It is somewhat adhesive, and though the specimen was collected about fifteen years ago, it still adheres to paper if lightly pressed. The sporodochia have broad bases, up to 0·4 mm. broad, and 0·3 mm. high, but in some the base is almost absent. The bases have the same colour and appearance as the stroma, and are slightly longitudinally tomentose. The tip is short, white, conical, up to 0·15 mm. high, sometimes represented by a few scattered teeth only, in the available specimens. The conidia are arcuate, equally curved, tapering regularly to the tips, a few nearly straight, generally five-septate, 72–94 × 4 μ. This differs from the common Ceylon form in its shorter tip and subtranslucent waxy stroma.

Microcera Merrillii Syd. (Ann. Myc. XII, p. 576), on a scale on *Eugenia perpallida* from the Philippines, would appear to resemble the foregoing. I have examined the co-type, S. 259, Herb. Bureau Sci. Philippines, which contains very few stromata, and those all immature. The stromata are dark red, subtranslucent, waxy, covering the scale or spreading from it on one side rather more widely than in the usual form. The largest stroma found was flattened convex, about 0·8 mm. diameter. The structure of the stroma is not that of the true *Microcera* but that of *Microcera Fujikuroi*. Sydow describes the sporodochia as pale blood red, sessile, generally confluent in small masses 1–1·5 mm. diameter, and the conidia narrow fusiform, straight or subfalcate, three-septate, with acute tips, 40–60 × 3·5–4 μ. I was unable to find conidia in the co-type, but those described by Sydow evidently agree with those of *Microcera Fujikuroi*, not with those of *Microcera coccophila*. Sydow compared his species to *Microcera tasmanica* McAlp., but it has not the structure of the latter.

Both *Microcera Merrillii* and the Australian specimen on *Melaleuca* yield a white precipitate when treated with alcohol. That characteristic, however, is not confined to these subtranslucent forms, but has been noted in an opaque form from Grenada.

Hennings in 1903 (Engler's Bot. Jahrb. p. 57) described *Fusarium coccidicola* on a coccus on leaves of Tea, Ost-Usambara, East Africa. The sporodochia were said to be effused, waxy, cinnabar, with fasciculate, simple, septate, rosy-hyaline hyphae,

100–250 × 4 μ. The conidia were elongato-fusoid, falcate, multiguttulate or obsoletely septate, with subacute tips, pinkish hyaline, 80–100 × 3·5–4 μ. I have not seen the type specimen, but from the description of the stroma and the conidia, this would appear to be *Pseudomicrocera*.

C. Specimens on *Aspidiotus articulatus* on Coffee, Soto, West Africa. This collection was enumerated by Parkin. In general appearance, it resembles the Ceylon specimen on *Aspidiotus* on *Hevea*. In some cases the scale is surrounded by a narrow stroma, with a fibrillose margin which may spread out over the leaf for a distance of two or three millimetres; in others, no stroma is visible, and the bases of the sporodochia are partly hidden by the scale. The sporodochia lie flat on the leaf, radiating in star fashion from the scale. Their bases are small, not exceeding 0·2 mm. in height, but the white tip is well developed. The teeth are distinct down to the base; viewed from the lower surface, they may be widely separated or not. The conidia are of the usual type, arcuate, equally curved, with tapering points, three- to five-septate, readily collapsing, 92–134 × 3 μ.

This form differs from the common Ceylon species, only in the greater length of its conidia. It may be known as var. *longispora*.

D. Specimens on *Aonidia*, Ceylon. Specimens on *Aonidia crenulata* on *Memecylon* (Plate III, figs. 9, 10), and *Aonidia bullata* on *Nothopegia Colebrookiana* were described by Parkin. The former is common on a group of *Memecylon edule* in the Royal Botanic Gardens, Peradeniya; of the latter, I have only the specimens referred to by Parkin.

On *Aonidia crenulata*, the fungus forms a narrow stroma, up to 0·25 mm. wide, either all round, or at one side of, the scale. This stroma is pinkish-red, thin, compact, with a whitish, fimbriate margin, and often radially grooved. It usually grows centripetally over the scale, as well as centrifugally over the leaf, but the centre of the scale is generally left exposed. The scale appears red, or scarlet, owing to the growth of the fungus beneath it, and the naked centre is more vividly coloured than the stroma. In wet weather, the stroma is coral red; when dry, it has a delicate covering of scattered, whitish hyphae.

The sporodochium almost always arises at the inner edge of the stroma, so that it is perched on the top of the scale, as a rule. Also, it usually arises from the extreme edge, and is attached to the stroma, not over its whole base, but at one side, so that at first sight it appears to be disconnected from the stroma. Generally only one sporodochium is borne on each scale, but there may be two. It is usually oblique, rarely horizontal.

The total height of the sporodochium is up to 0·9 mm. The base is ovoid or cylindric, 0·4 mm. high and 0·3 mm. diameter, with a conical tip, 0·5 mm. long. When moist, the whole fungus is subtranslucent, pinkish-red or coral-red, but when dry it appears whitish or pinkish, and minutely pruinose.

The wall of the conical tip may be divided into teeth, as in the common form, but it is frequently continuous, except for a fissure extending along the whole length of the tip in the median line on the lower surface. Sometimes this fissure is narrow, rather broader above than below: in other cases, its sides are curved as shown in diagram 20, Plate V. The hyphae which form the wall of the tip are 4 μ in diameter, equal, septate, and united by ladder connections. The wall is rather thick and fimbriate at the apex, and numerous long free hyphae, parallel, and similar to those which compose the wall occur on the inner side.

In dry-weather forms, the sporodochium is uniformly conical without any evident constriction between the base and the tip. At other times, the sporodochium is constricted, and often curved.

The conidiophores are short, 30–66 μ, simple or branched. The conidia are arcuate, tapering uniformly to the ends, usually three-septate, a few five-septate. The septa are obscure, and apparently tardily developed. It is not uncommon to find the majority of the spores without septa. The aseptate tips are usually long, up to 20 μ. Measurements of different collections have given the following dimensions: 70–86 × 4 μ; 84–96 × 3·5–4 μ; 66–82 × 3·5–4 μ; 38–64 × 3–4 μ, some only 16–30 μ (dry weather); 70–80 × 3·5–4 μ.

When the tip is filled with spores, the mass projects at the apex as a coral-red point.

The specimen on *Aonidia bullata* mentioned by Parkin is similar to the above, but the sporodochia arise in the middle of the stroma, not at its edge. The spores are arcuate, three-septate, 70–80 × 4 μ.

A curious abnormality of the form on *Aonidia crenulata* has been collected. It occurred on *Memecylon* with the normal form, the latter usually on the under surface of the leaf, and the abnormal form on the upper. No scale insects were visible on the upper side of the leaf, but it was covered with small, curved, hyaline, claw-like thorns, standing up obliquely. Each of these thorns arises from a broad, circular, hyaline, membranous, scarious patch up to 0·8 mm. diameter, which can readily be detached from the leaf. The thorn-like projection is about 0·6 mm. high, strongly laterally compressed, and about 0·25 mm. broad. The convex edge is regular, but the lower edge, viewed

from the side, appears to be interrupted by a deep narrow sinus (Plate V, fig. 8 *b*). Viewed from the convex edge, two auricles are seen, projecting one on either side at the base (fig. 8 *a*), while, from the concave side, it is seen that the two sides of the structure fold together and nearly meet above, but separate again widely near the base (fig. 8 *c*).

The wall of this structure is thin, continuous, and hyaline, and is composed of parallel hyphae, about 3 μ diameter, united side by side in a continuous sheet, and joined laterally by ladder connections. Within it, at the base, there is a very minute parenchymatous mass of hyaline cells, from which a few unbranched conidiophores arise, but no conidia have been found.

A comparison of figs. 8 and 20, Plate V, will make it clear that these thorns are the walls of the conical tips of the *Pseudomicrocera*, and their structure supports that interpretation. But they are not *Pseudomicrocera* sporodochia from which the conidia have disappeared, as the base is practically entirely lacking. For some reason, only the wall of the tip has been developed, and that has taken the form of a hyaline membrane. They appear to have grown on very small specimens of *Aonidia*.

It may be noted that the tendency to produce scarious membranes is well-marked in most of the fungi which grow on scale insects. It occurs, for example, in *Aschersonia* and *Hypocrella*, where the stroma is often surrounded by a scarious hypothallus; and one may meet with the same hypothallus, indiscriminately, in gatherings of *Sphaerostilbe* and *Microcera*.

SPHAEROSTILBE.

Sphaerostilbe coccophila Tul.

This species was first described by the Tulasnes in Selecta Carp. Fung. I, p. 130 (1861), where they cited the specimens *Microcera coccophila* Desm., Desmazières, Plantes Cryptogames de France, Ed. II, Ser. I, No. 1350 as the conidial stage, and Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda, Nos. 262 and 269 as the perithecial stage. Rabenhorst 262 had been issued as *Nectria episphaeria* Tode, and 269 as *Microcera coccophila* Desm.

The description was repeated in Selecta Carp. Fung. III, p. 105, where Rabenhorst 262 only is cited for the perithecial stage, but Desmazières, Plantes Cryptogames de France, Ed. I, Ser. I, No. 1750 is added to the former citation for the conidial stage.

Desmazières 1350 and 1750 were collected near Caen (Normandy) and Rabenhorst 262 and 269 at Florence, Italy.

According to the Tulasnes' description, their species forms a

narrow byssoid stroma, pallid or pale rose, round the scale. The synnema is about a line high, with a deep red head consisting of linear lanceolate, curved conidia, three- to five-septate, 65 × 6 μ. The perithecia arise at the base of the synnema, or on stromata which lack synnemata; they are minute, globose, obtusely and very shortly papillate, very smooth, shining red, fleshy and fragile, collapsing when dry, clustered in groups of three to five. The asci are cylindric, 60–80 × 6·5 μ, obtuse, subsessile, eight-spored. The ascospores are ovate, subhyaline, one-septate, somewhat constricted at the septa, ends obtuse, 10 × 5 μ.

Seaver (Mycologia, 1, p. 180) regards *Sphaerostilbe coccophila* Tul. as identical with *Nectria subcoccinea* Sacc. and Ellis, and suggests that it is also identical with *Nectria aurantiicola* B. and Br. and *Nectria aglaothele* B. and C. He states that the synnema consists of a short stout stalk with an orange head, the conidia being straight, or more often curved, fusiform, three- to seven-septate, 50–90 × 5–6 μ, occasionally shorter; and that the perithecia are more or less caespitose, bright orange, with a prominent, rather acute ostiolum, and contain cylindrical asci, 75 × 8–10 μ, with elliptical or subelliptical spores, 12–18 × 7–9 μ. He cites the American specimens, Ellis, North American Fungi, No. 1333 (issued as *Nectria subcoccinea*); Ravenel, Fung. Car. Exsicc., No. 57 (issued as *Nectria muscivora* Berk.); and Hume, Florida, No. 39. The dimensions given for the ascospore give occasion for doubting the identity of the fungus described by Seaver with that described by the Tulasnes.

Von Höhnel and Weese state that *Nectria subcoccinea* Sacc. and Ellis (1882) is identical with *Nectria Colletiae* Rehm (1898) and *Nectria coccidophthora* Zimm. (1901) *from the descriptions*; and again that *Nectria Colletiae* Rehm is identical with *Nectria subcoccinea* Sacc. and Ellis, and, *fide* Seaver, with *Sphaerostilbe coccophila* Tul.

In order to clear up the synonymy suggested by the authors cited, an examination has been made of as many as possible of the type specimens, or of authentic specimens, of the species referred to. *Nectria Colletiae* Rehm is the only species not available in Herb. Kew, Herb. British Museum, or Herb. Peradeniya. The conclusions arrived at are stated here briefly; reference to the specimens examined will be made when dealing with the species individually.

To differentiate accurately between the different species of *Microcera* it is necessary to have the perithecial stages. In the conidial stage, they are all very similar, and though it appears possible to distinguish the conidia of *Microcera coccophila* from those of *Microcera aurantiicola* when both have been collected

in the tropics, the distinction fails when the specimens have originated in temperate countries.

The Tulasnes noted that in their perithecial specimens from Florence, Rabenhorst 262 and 269, the conidial stage was rare. In the specimens in Herb. British Museum and Herb. Kew, Rabenhorst 262 is apparently entirely perithecial, while Rabenhorst 269 contains the conidial stage, as well as immature perithecia. The latter is a poor development, the scales being scattered, not crowded as in other specimens from Florence. Although Rabenhorst stated, in the description which accompanied the specimen, 262, "ascos non vidi," it contains mature perithecia, and from these it is evident that the species is identical with that described from Ceylon by Berkeley and Broome as *Nectria aurantiicola*.

The conidial stage in Desmazières 1350 will be described later. But the specimens also contain perithecia, and these are identical with *Sphaerostilbe flammea* Tul.

Sphaerostilbe flammea differs from *Nectria aurantiicola* both in its perithecia and its ascospores. Consequently, *Sphaerostilbe coccophila* Tul., according to the specimens cited by the Tulasnes, consists of the perithecial stage of one species and the conidial stage of another. The Tulasnes named their species on the assumption that Desmazières' fungus was the same as that from Florence. But *Microcera coccophila* Desm. is the conidial stage of *Sphaerostilbe flammea*, not of *Sphaerostilbe* (*Nectria*) *aurantiicola*.

The synonymy quoted above (p. 110) is correct in that *Nectria aglaothele* and *Nectria subcoccinea* are identical with the species issued by Ravenel as *Nectria muscivora*; but they are not identical with the perithecial stage of *Sphaerostilbe coccophila*, though their conidial stage is *Microcera coccophila*. Nor are they identical with *Nectria aurantiicola* or *Nectria coccidophthora*.

It might be suggested that, as the perithecial stage of *Sphaerostilbe coccophila* is identical with *Nectria aurantiicola*, the latter name should be discarded. It would, however, still be necessary to retain *Microcera coccophila* for the conidial stage of *Sphaerostilbe flammea*, and the use of the same specific name for the two different stages of two different, though closely allied, species would undoubtedly lead to confusion. Moreover, it is quite certain that the Tulasnes' name was chosen on erroneous grounds.

One is loth to propose the abolition of a name which has been so widely employed in the literature of economic mycology. On the other hand, this reluctance is tempered by the knowledge that the name has usually been wrongly applied. *Sphaerostilbe coccophila* Tul., as it stands at present, is a compound species,

and it would certainly appear preferable to employ the names of species which have been more accurately defined, viz. *Sphaerostilbe flammea* Tul., *Sphaerostilbe aurantiicola* (B. and Br.), and *Sphaerostilbe coccidophthora* (Zimm.).

The three species of *Sphaerostilbe* parasitic upon scale insects, though undoubtedly closely allied, may be distinguished by the following characters.

Sphaerostilbe flammea Tul. Perithecia usually caespitose on a well-developed stroma, bright orange red, glabrous, globose, collapsing centrally; ostiolum minute, conical or inconspicuous; ascospores 12–19 × 5–8 μ.

Sphaerostilbe aurantiicola (B. and Br.). Perithecia usually scattered without evident stroma, dark red, subtranslucent, conoid, glabrous or with a few yellow granules, collapsing laterally; ostiolum papillate; ascospores 9–14 × 4–6 μ.

Sphaerostilbe coccidophthora (Zimm.). Perithecia usually scattered on a slight stroma, dark red, covered with yellow granules, conoid or subglobose, subtranslucent, collapsing laterally; ostiolum papillate; ascospores 13–22 × 7–9 μ.

In *Microcera coccophila*, the conidia are more often fusoid and straight from tip to tip than in *Microcera aurantiicola*; the typical conidium of the latter, and of *Microcera coccidophthora*, is almost straight with falcate tips. In *Microcera aurantiicola*, the septa of the conidia are usually more strongly defined than in *Microcera coccophila* or *Microcera coccidophthora*.

Berkeley and Broome described the perithecia of *Nectria aurantiicola* as "in stromata erecto sitis," and they gave a figure illustrative of that. Their description and figure are supported by a specimen *ex* Herb. Broome in Herb. British Museum, which shows that the erect stroma is a *Microcera* synnema. Parkin, in his figure No. 9, showed the perithecia situated in two instances on the stalk of the synnema. That, however, is not the usual mode of occurrence of the perithecia in *Nectria aurantiicola* and it is exceptional, even in Broome's specimen. In the most general case, the perithecia occur on scale insects which do not bear the conidial stage. When they occur in company with the conidial stage, they do sometimes occur on the stalks of the old synnemata, and developing perithecia may also be found in the head among the conidia. But out of about twenty Ceylon gatherings, I have only one in which they occur in those positions No. 542, Erbar. Crittogam. Ital., Ser. II, issued as *Sphaerostilbe coccophila*, also bears developing perithecia on the synnemata.

The Tulasnes figured *Sphaerostilbe flammea* with developing perithecia on the synnema. The type specimen of *Nectria laeticolor* B. and C. which is *Sphaerostilbe flammea* has perithecia

in that position in some instances, and the same is true of the type specimen of *Microcera pluriseptata* Cke. and Massee, which is identical with *Microcera coccophila* Desm., the conidial stage of *Sphaerostilbe flammea*. This has not yet been observed in *Sphaerostilbe coccidophthora*, but the available collections of the latter species are few in number.

Relying upon Berkeley and Broome's description and figures, von Höhnel has transferred *Nectria aurantiicola* to *Corallomyces* because it has perithecia on the synnemata. Obviously, in that case, *Sphaerostilbe flammea* must be transferred to *Corallomyces*, and this has been effected by von Höhnel in Herb. Kew, as far as regards the type of *Nectria laeticolor*. On this classification, the closely-allied *Nectria coccidophthora* must be left in *Sphaerostilbe*. But the production of perithecia on the synnemata is exceptional in both *Sphaerostilbe aurantiicola* and *Sphaerostilbe flammea*, and it does not seem reasonable to separate those two generically from *Sphaerostilbe coccidophthora* on a character which is seldom developed.

The genus *Corallomyces* was established by Berkeley and Curtis in 1853, the type species being *Corallomyces elegans*, described from specimens from Surinam in the Schweinitz Herbarium. It was said to have a branched stroma, with filiform and palmate branches, and to be a Hypocreaceous genus corresponding to *Xylaria*. Berkeley and Curtis published figures of their species (Journ. Acad. Sci. Philadelphia, n.s. II, Table XXV, fig. 2), showing short, simple, or slightly branched, clavae, in one case flattened at the tip. Another figure, by Lindau, was published in Engler-Prantl., Pflanzenfamilien, Th. I, Abt. I, p. 366; it shows a shrubby growth of suberect, much branched stems, arising from the same point. The latter figure is said to be original, but there is no indication of the origin of the specimen from which it was taken. The type specimen of *Corallomyces elegans* in Herb. Kew, "*Corallomyces elegans* B. and C., *Sphaeria pseudovillosa* Schw., Surinam, Herb. Schwein." is a dense group of old synnemata, arising side by side from the substratum; some of these are once branched, others simple, and there appear to be a few horizontal rhizomorphs in addition; the perithecia are borne on the old synnemata. There is nothing in the type specimen which would support Lindau's figure.

Corallomyces is merely a *Sphaerostilbe* which has produced perithecia on the old synnemata. The type species, *Corallomyces elegans*, is closely allied to *Sphaerostilbe repens*, a rhizomorphic species which may produce perithecia on the rhizomorphs or on the old synnemata. It would appear to be the rule rather than the exception, that species of *Sphaerostilbe* may produce

perithecia on the old synnemata. The distinguishing character of *Corallomyces* is the possession of a branched, filiform stroma, resembling that of a *Xylaria*, but that is based on a mistaken interpretation of the type specimen. Von Höhnel places in *Corallomyces* those species of *Nectria* which have the perithecia situated on a stalk-like stroma; in dealing with *Nectria aurantiicola*, he states (Fragm., No. 729) "Da die Perithecien auf einem stielartigen Stroma entstehen ist der Pilz eigentlich ein *Corallomyces*." But he does not appear to recognise that the stalk-like stroma is an old synnema, nor that the occurrence of the perithecia in that position is exceptional.

The Tulasnes employed the name *Sphaerostilbe* in Selecta Carp. Fung. I, 130 (1861), though they did not publish the generic description until 1865, in vol. III, p. 99. They included in the genus (in the following order), species with minute simple conidia and a *Stilbum* conidiophore, viz. *Sph. aurantiaca*, *Sph. gracilipes*, and *Sph. cinnabarina*, and species with long lanceolate, septate conidia and a *Microcera* conidiophore, viz. *Sph. flammea* and *Sph. coccophila*. Their genus is evidently heterogeneous, as it contains species which differ in their conidial stages, and it can be naturally divided into two genera, one with simple conidia and the other with lanceolate, septate conidia.

Corallomyces is prior to *Sphaerostilbe*. If the generic character assigned to the former is accepted, it will be necessary to retain both genera, and to transfer species from *Sphaerostilbe* to *Corallomyces*, when specimens of known species of *Sphaerostilbe* are collected which have developed perithecia on the old synnemata. And in that case both *Sphaerostilbe* and *Corallomyces* will be heterogeneous, for the latter must contain *Sph. repens*, with simple conidia, and *Sph. flammea*, with septate conidia, while the former will contain the parallel species, *Sph. aurantiaca* and *Sph. coccidophthora*. Alternatively, the misinterpreted generic character might be discarded, and all species of *Sphaerostilbe* referred to *Corallomyces*, but *Corallomyces* would still be heterogeneous.

The most logical course would appear to be to discard the false generic character of *Corallomyces*, and to include in the genus all species which are co-generic with the type specimen, *Corallomyces elegans*. The latter has *Nectria* perithecia, and a stilboid conidial stage with simple conidia, and is co-generic with *Sph. repens*, *Sph. variabilis*, *Sph. aurantiaca*, *Sph. gracilipes*, and *Sph. cinnabarina*. *Corallomyces* will then be equivalent to the first section of *Sphaerostilbe* of Tulasne, while the name *Sphaerostilbe* can be retained for those species which have a *Microcera* conidial stage and long septate conidia, viz. *Sph. flammea*, *Sph. aurantiicola*, and *Sph. coccidophthora*.

Corallomyces, Char. emend. Perithecia of *Nectria*; conidial stage stilboid; conidia continuous.

Sphaerostilbe, Char. emend. Perithecia of *Nectria*; conidial stage *Microcera*; conidia elongated, septate.

In re-describing *Microcera coccophila*, the Tulasnes stated that *Microcera* differed little from *Atractium* Link. Link established the genus *Atractium* in Magazin Gesellsch. Naturforsch. Freunde zu Berlin, Jahrg. III, 1809, p. 10, the type species being *Atractium Stilbaster*, and the generic characters, "Stroma elongatum, capitatum. Sporidia fusiformia, *non septata*, capitulo instrata." Link's figure shows a *Stilbum* with minute oval conidia; his type species is listed in Saccardo as *Atractium gelatinosum* (Pers.) Sacc. Subsequently (*ibid.* VII, p. 32) Link included in his genus *Atractium ciliatum* (*Tubercularia ciliata* Alb. and Schw.), with the note that he had seen septate conidia in this plant; the latter now stands as *Volutella ciliata*. Hence Link tacitly extended his genus to include species with septate spores, and in this he was followed by Berkeley and Saccardo, who published an amended generic description in Michelia, II, p. 32, citing *Atractium Therryanum* Sacc. as their type species. The genus *Atractium* would appear to require revision, but that is not relevant to the present discussion. The Tulasnes' statement is probably to be explained on the supposition that their knowledge of *Atractium* was based on the specimens sent to them by Berkeley as *Atractium flammeum* Berk. and Rav., since the latter species is identical with *Microcera coccophila* Desm.

Sphaerostilbe flammea Tul.

This species was described by the Tulasnes in 1856 as *Stilbum flammeum*, the name being changed to *Sphaerostilbe flammea* in 1861. Its conidial stage had been described by Berkeley in 1854 as *Atractium flammeum* Berk. and Rav. That *Sphaerostilbe flammea* is parasitic on scale insects appears to have escaped notice hitherto, though that is the case with all the specimens enumerated below. When its real host has been observed, the perithecial stage has been re-named, or the conidial stage has been correctly referred to *Microcera coccophila* Desm. (1848), which is identical with *Atractium flammeum* Berk. and Rav. (1854).

The fungus forms a white or pinkish tomentose or byssoid stroma, extending from or over the scale in many cases, but this is sometimes lacking. The synnemata (Plate III, fig. 8), in the North American and European forms, are usually small, either clavate, up to 0·6 mm. high and 0·25 mm. diameter, or conical, 0·5 mm. high, 0·25 mm. diameter, or, more generally, flattened pulvinate, up to 0·75 mm. long, 0·5 mm. broad. But

in tropical forms, they may attain a height of 2·5 mm. Both the stalked and sessile forms are usually clothed at the base with erect fascicles of hyphae arising from the basal stroma. The conidia are fusiform, straight, or straight with falcate tips, or slightly, but uniformly curved; they are up to eleven septate, but the septa are usually obscure, and frequently poorly developed, only two or three being present and those irregularly spaced; they measure 50–105 × 5–7 μ, as a rule, but sometimes are only 35 μ long. The short, curved, triseptate *Fusarium* conidium 18 × 4 μ, which is common in *Sphaerostilbe aurantiicola* (Plate V, fig. 11), has been observed in one American gathering.

The perithecia are crowded together on a well-developed stroma which often completely hides the scale insect (Plate III, fig. 7). They occur, in numbers up to about eighteen, in groups which may be a millimetre in diameter, and are usually at first partly covered by fascicles of hyphae arising from the stroma. When mature, they are bright orange red, darker round the ostiolum, glabrous, slightly rugose, opaque, globose, 0·3 mm. diameter, collapsing centrally as a rule; the ostiolum is minute, conical, acute, or scarcely evident. The cells of the perithecial wall are somewhat obscure, and the colour, by transmitted light, varies, according to the degree of maturity of the specimen, from yellow to red brown. The asci are cylindric, scarcely pedicellate, eight spored, spores obliquely uniseriate, 90–116 × 8–10 μ. Paraphyses are present, but diffluent. The ascospores are elliptic, ends obtuse, one-septate, not constricted, hyaline or yellowish, minutely verrucose, 12–19 × 5–8 μ.

The perithecial stage of this species was first collected by Ravenel in North America but the specimens were assigned by Berkeley to *Nectria muscivora* B. and Br. The latter species had been found at King's Cliffe, England, and had been described by Berkeley and Broome in Ann. Mag. Nat. Hist., Ser. 2, vol. VII, p. 188 (1851). It was parasitic on mosses. After their description, Berkeley and Broome added the note "We have this species from South Carolina on *Jungermanniae*." An examination of the type specimen of *Nectria muscivora* shows that it is not the same as Ravenel's species. *Nectria muscivora* has perithecia which have prominent papillaeform ostiola, and are embedded up to half their height, or up to the ostiolum, in a white floccose weft of mycelium; the perithecia are now amber coloured, the wall appearing hyaline by transmitted light; the ascospores are narrow oval to subfusoid, sometimes subcymbiform, with apices rounded or subacute, one-septate, rough, 15–24 × 6–8 μ; it is listed in Saccardo as *Calonectria*, but I was unable to find more than one septum in the spores of the specimen examined by me.

In 1854 (Ann. Mag. Nat. Hist., Ser. 2, vol. XIII, p. 461), Berkeley and Broome described a new species, *Atractium flammeum*. The type specimen was collected by J. Ralfs, on the bark of living willows, but the species was assigned to Berkeley and Ravenel, because it had been found "in similar situations, peeping up from beneath lichens," by Ravenel in South Carolina: it was described as "scarcely half a line high, cylindric, flame red, pruinose below, head convex, spores ·003 inch long, curved, fusiform, hyaline with six or more septa, seated on long sporophores." Berkeley and Broome added the note "Mr Ravenel in a late communication suspects it to be a state of some *Nectria*"; and on the herbarium specimens, Ravenel 1433 bears the note by Ravenel, "Can it be *Sphaeria muscivora* Berk.," while Ravenel 976 is marked by him "?*Sphaeria muscivora* Berk."

Ralfs's specimens in Herb. Kew, *ex* Herb. Berk. are "No. 90, *Atractium flammeum* Berk. and Rav., in Salix viva, Penzance," and "195, *Atractium flammeum* Berk. and Rav., in Fraxinum adhuc vivum, Penzance," with a drawing of the spore marked $\frac{1}{333}$. In Herb. B.M., *ex* Herb. Broome, there is a specimen from Ralfs, but it is marked "*Microcera coccophila* Desm., 468 *d*, on Willows, Penzance, January, J. Ralfs." None of these specimens is dated. In all the British specimens, the fungus is parasitic on *Chionaspis salicis*.

Of Ravenel's specimens, Herb. British Museum has, *ex* Herb. Ravenel, a specimen marked by Ravenel "*Atractium flammeum* Berk. and Rav. var. *minor*, S.C., Fasc. v, 80, Ravenel"; another with printed label, "86, *Atractium flammeum* Berk. and Rav. var. *minor*, ad corticem vivum Aceris"; "976, *Atractium flammeum* B. and R., Aest., ad Parmeliam, S.C., H.W.R."; "1433, *Atractium flammeum* B. and R., Feb., ad muscos, S.C., H.W.R."; "1843, *Atractium flammeum* B. and Rav., on *Acer rubrum*, S.C."; "1843, *Atractium flammeum* B. and Rav., on bark of living *Acer*, Aiken, S.C., H.W.R." Both 86 and 1843 contain perithecia.

In Herb. Kew, *ex* Herb. Berk., there are "(*Atractium flammeum* Berk. and Rav.), 976, *Sphaeria muscivora*? Berk. (in corticem non) on *Parmelia*, S.C., H.W.R.," the words in parentheses having been added by Berkeley; "(*Atractium flammeum* Berk. and Rav.), 1433, Feb., on mosses, *Frullania virginica*, S.C., H.W.R., Can it be *Sphaeria muscivora* Berk."; "1843, *Atractium flammeum* B. and R., on *Acer rubrum* (living trees), Aiken, S.C., H.W.R."; "No. 2958, *Stilbum*, Car. Inf."; and a packet, *ex* Herb. Cooke, bearing a label in Ravenel's handwriting "*Atractium flammeum* Berk. and Rav. var. *minor*."

All the foregoing specimens are the same, and are *Microcera*

coccophila Desm., while the perithecia are, as suggested by Ravenel, identical with the species referred by Berkeley to *Nectria muscivora* B. and Br. It may be noted that in Grevillea IV (1875), p. 47, Berkeley referred Ravenel 1843 to *Sphaerostilbe flammea* Tul., and, apparently, though the record is not clear, Nos. 976 and 1433, on *Parmelia* and *Frullania virginica*, to a "very distinct species on *Moquolia glauca*, Car. Inf. No. 5005 (*Atractium pallidum* B. and C.) which may possibly be the conidiiferous form of *Nectria muscivora*."

Berkeley sent specimens of *Atractium flammeum* to the Tulasnes, who described them as *Stilbum flammeum* in Acta hebdom. Acad. Sci. par., XLII, p. 704, and in Ann. Sci. Nat., Ser. IV, vol. V (1856), p. 114. They recorded the perithecial stage, but did not give the dimensions of the ascospore. In Selecta Carp. Fung. I, p. 130 (1861), they referred to it as *Sphaerostilbe flammea* (name only), while in vol. III, p. 104 of the same work (1865), they repeated their former description under the latter name. In the explanation of their plate, the Tulasnes stated that the description and figures were derived from an American specimen sent by Berkeley, though the fungus figured is said to be on "Saligni corticis frustrum," which is the supposed habitat of the European species. Their figure is not a good one, either of the perithecia or the conidial stage.

It is curious that the Tulasnes did not note that *Atractium flammeum* was identical with *Microcera coccophila* Desm. They did however state that *Microcera* did not differ from *Atractium* (Selecta Carp. Fung. I, p. 130). Specimens collected subsequently near Penzance were referred to *Microcera coccophila* by Broome, and later specimens from Ravenel bear the latter name.

Seaver's description of *Sphaerostilbe coccophila* (see p. 110) evidently refers to *Sphaerostilbe flammea*, and, of the specimens cited by him, Ellis, North American Fungi, No. 1333, and Ravenel, Fung. Car. Exsicc., No. 57, are *Sphaerostilbe flammea*. I have not seen Hume, Florida, No. 39.

Ellis and Everhart, North American Pyrenomycetes, p. 111, describe *Sphaerostilbe flammea* as having globose, bright red, nearly smooth perithecia crowded on or near the conidiophorous stroma; asci obovate oblong, eight-spored, sporidia ovate, obtuse, uniseptate, hyaline, slightly constricted, 12–16 × 5–6 μ; conidia 80–100 × 6·5, 6–9 septate. They cite the conidial fungus, Ravenel, Fung. Car. V. 86, which was issued as *Atractium flammeum* var. *minor*, and give the localities "on maple bark, Carolina (Ravenel)," and "on *Salix*, Louisiana, Langlois."

Seaver states that the ascospores of *Sphaerostilbe flammea* are elliptic to subfusoid, 15 × 6–7 μ. He cites the specimens Ellis

and Everhart, North American Fungi, 2nd Series, 3311; Langlois, 2290; Ellis, New Jersey; Dearness, Ontario, Canada.

Specimens which have been identified as *Sphaerostilbe flammea* Tul. are not numerous in British Herbaria, and many are incorrectly determined. Ellis and Everhart, North American Fungi, 2nd Series, No. 3311, *Sphaerostilbe flammea* Tul., and No. 3312, *Atractium flammeum* Berk. and Rav., are represented in Herb. B.M., but neither of these is correct. 3311 has densely clustered perithecia in cracks in the bark: the specimens are chiefly immature, and the available ascospores are narrow-oval or oblong-oval, 6–10 × 2–2·5. 3312 is a more immature gathering of the same species, and does not bear any *Atractium*.

Under *Sphaerostilbe flammea*, Herb. Kew has "Ravenel, Fung. Car. Exsicc., No. 5, 86," and "*Sphaerostilbe flammea* Tul., Rav. v, 86, sub *Atractium flammeum* v. *minor*, on *Acer*." The latter specimen is *ex* Herb. Cooke.

I have examined the following specimens of *Sphaerostilbe flammea* from Ravenel, which were referred to *Nectria muscivora*. Specimen *ex* Herb. Ravenel in Herb. B.M., marked "45, *Sphaeria muscivora* Berk., Nov., on *Jungermannia* growing on *Acer rub.*, S.C., H.W.R."; this has synnemata clavate, 0·5 mm. high, 0·05 mm. diameter below, expanding to 0·25 mm. above, or pulvinate, 0·5 × 0·25 mm.; conidia 60–80 × 5–6 μ, nearly straight, up to nine-septate, septa obscure and poorly developed, usually only three or four and irregularly distributed; conidia tend to collapse laterally; ascospores 12–19 × 6–8 μ. Specimen *ex* Herb. Ravenel in Herb. B.M., marked "45 *Sphaeria muscivora* Berk., Autumno, apud *Jungermannia*, S.C., H.W.R.," with drawing of ascospore marked "·0007 inch long"; apparently a duplicate of the former; both contain many synnemata but few perithecia. Specimen *ex* Herb. Ravenel in Herb. B.M., marked 1156 and spore measurement as above; this has caespitose collapsed perithecia. Ravenel, Fungi Car. Exsicc., No. 57, in Herb. Kew and Herb. B.M.; ascospores 13–17 × 6–8 μ. Specimens in Herb. Kew and Herb. B.M., *ex* Herb. Ravenel, "3263, *Nectria muscivora* Berk., on moss on *Acer*, St Johns (indecipherable), S.C., Apr. 81, H.W.R."; perithecia clustered in groups up to 1 mm. diameter, orange red, collapsing centrally, darker round the ostiolum, pruinose with white granules; ascospores 12–17 × 7–8 μ; synnemata flattened pulvinate up to 0·6 × 0·4 mm., or clavate, 0·6 mm. high, 0·25 mm. diameter; conidia nearly straight, 85–105 × 6 μ, up to eleven septate, septa obscure; conidia fairly abundant; the pulvinate synnemata bear numerous developing perithecia. Specimen in Herb. Kew, marked "*Nectria muscivora*, Car. Aust." which is apparently part of one of the Ravenel specimens with *Jungermannia*.

Specimen in Herb. Kew, marked "99, *Nectria muscivora*, on mossy trees, Apr., H.W.R., Houston, Texas."

The following Ravenel collections were correctly assigned to *Microcera coccophila*. Specimens in Herb. Kew and Herb. B.M., "Ravenel 2527, *Microcera coccophila* Desm., on living *Rhus*, Darien, Ga." Specimens in Herb. Kew and Herb. B.M., *ex* Herb. Ravenel, "3376, on exposed root of Water Oak, Darien, Ga., Nov. 81"; these appear to be the same gathering as "Ellis, N.A. Fungi, No. 1229, *Microcera coccophila* Desm., on bark of *Quercus* (? *palustris*), Darien, Ga., H. W. Ravenel," of which there is a specimen in Herb. B.M.; the sporodochia are pulvinate, oval or circular, up to 0·75 × 0·5 mm., sometimes confluent; conidia 75–80 × 5–6 μ, obscurely septate; a small curved *Fusarium* conidium, three septate, 18 × 4 μ, is present; some of these specimens bear clustered perithecia, with ascospores 14–17 × 6–7 μ.

Sphaerostilbe flammea was described as *Nectria laeticolor* by Berkeley and Curtis in Journ. Linn. Soc., x. (1868), p. 377, on specimens from Cuba, "on trees among hepatics." It is on a scale insect. Berkeley and Curtis cite the numbers 458, 542, 555. Specimen 458 is missing in Herb. Kew: the sheet is marked by Berkeley, "immature." 542 and 555 are *Sphaerostilbe flammea*, sometimes with perithecia on the synnemata. Specimens distributed as "765 Fungi Cubenses Wrightiani" are part of these gatherings. *Nectria laeticolor* is cited by Seaver as a synonym of *Sphaerostilbe flammea*. There is another Cuban specimen of *Sphaerostilbe flammea* among the unnamed *Dubiae* in Herb. Kew, apparently from Curtis.

Berkeley and Curtis subsequently, in Grevillea, iv, p. 45 (1875), described the same species as *Nectria aglaothele*, stating that it grew on the remains of a coccus. The type specimen of *Nectria aglaothele* in Herb. Kew is marked by Berkeley, "Sprague, on Alder, New England, No. 5378"; its ascospores are 13–17 × 6–8 μ. There are apparently duplicates of this collection in Herb. B.M. *ex* Herb. Bloxam, and in Herb. Kew *ex* Herb. Cooke and Herb. Currey, all marked by Berkeley "*Nectria muscivora* Berk., on alder, Mass." It would seem that Berkeley had discovered, after distributing the duplicates, that the American specimens which he had assigned to *Nectria muscivora* had been incorrectly determined.

In Grevillea, iv, p. 47 (1875), Berkeley recorded "*Sphaerostilbe coccophila* Tul., on *Alnus serratula*, Pennsylvania, Michener, No. 4316." The specimen in Herb. Kew is marked "4316, *Sphaerostilbe coccophila* Tul., *Atractium coccigena* B. and C., on *Alnus serratula*, Penn., Michener." It is *Microcera coccophila* Desm., the conidial stage of *Sphaerostilbe flammea*.

In 1882, Saccardo and Ellis (Michelia, II, p. 570) described this species as *Nectria subcoccinea* Sacc. and Ellis. Specimens were distributed by Ellis in North American Fungi, No. 1333, on bark of living alder, West Chester, Pa., October 1881, Everhart and Haines. In Ellis, 1333 in Herb. Kew and Herb. B.M., the perithecia are globose, clustered, with a minute conical ostiolum; the asci are 100–116 × 8 μ, cylindric, spores uniseriate or obliquely uniseriate; ascospores 13–18 × 6–7 μ; the synnemata are conical, 0·35 mm. high, 0·25 mm. diameter, clothed below with erect fascicles of hyphae, or pulvinate, 0·5 × 0·25 mm.; the conidia are nearly straight, or curved at one end, up to six septate, 35–45 × 5–6 μ. This example has unusually short conidia.

Ellis and Everhart, in North American Pyrenomycetes (1892), stated that *Nectria subcoccinea* Sacc. and Ellis was identical with the Ravenel specimens in Fungi Car. Exsicc., I, No. 57, which Berkeley had assigned to *Nectria muscivora*, and they drew up their description of the latter species from the specimens, Ellis, North American Fungi, No. 1333, which had been issued as *Nectria subcoccinea*. They noted that neither Ravenel's specimens nor Ellis 1333 showed anything of the white lanose patches mentioned in the original description of *Nectria muscivora*, but they nevertheless retained Berkeley's identification.

In Grevillea, IV, p. 45 (1875), Berkeley described a *Nectria* as *Nectria viticola* B. and C. This, according to von Höhnel and Weese in Herb. Kew, is *Nectria sanguinea*. It is not on a scale insect. But Passerini, in 1875, found a *Nectria* on *Vitis vinifera* in Liguria, which he referred, in Pirotta, Fung. Vit. VII, p. 45, to *Nectria viticola* B. and C. He sent specimens to Kew, labelled "*Nectria viticola* B. and C., Grevillea, Dec. 1875, nisi abstent conidia fusiformia, Ropallo, Liguria, ad sarmenta viva vitis vinifera, Iunio 75, G. Passerini." Cooke recognised that this was not the same as Berkeley and Curtis's species, and described it in Grevillea, XII, p. 81, as *Nectria Passeriniana* Cke. The specimen in Herb. Kew is marked by von Höhnel and Weese, "*Nectria viticola* Pass. = *Endothia* (?) *Passeriniana* (Cooke) Weese. *Hypocreopsis*??." This is a clustered *Nectria* with a well-developed stroma, covering a scale insect. Its ascospores are up to 18 × 8 μ. It has minute pulvinate synnemata and *Microcera* conidia. There is no doubt that this is *Sphaerostilbe flammea*.

A specimen from E. W. Berger, on scale of oak (*Chrysomphalus obscurus*), Florida, in Herb. British Museum, sent as *Sphaerostilbe coccophila* Tul., is *Sphaerostilbe flammea*. The ascospores are 13–18 × 7–8 μ; the synnemata are flattened pulvinate; the conidia are 75–80 × 5–6 μ, nearly straight, or

straight with falcate tips, up to nine-septate with well-defined septa.

Prof. C. Spegazzini has kindly forwarded me specimens of this species, on a scale insect on pine needles (locality?) January 20, 1916, and La Plata, May 19, 1919, under the MSS. name, *Nectria coccicida*. In these the synnemata may be clavate, up to 0·6 mm. high, 0·12 mm. diameter at the base, 0·25 mm. diameter above (Plate III, fig. 8), but the majority are conoid, up to 0·5 mm. high, 0·3 mm. diameter, or flattened pulvinate, up to 0·4 mm. long, 0·2 mm. broad, and 0·25 mm. high; they are situated on, or at the side of, the scale, and usually arise from a well-developed stroma; the conidia are straight, or straight with falcate tips, or uniformly curved, pale yellow under a low magnification, hyaline when more highly magnified, up to nine-septate, ends obtuse, 80–88 × 6–7 μ. The asci measure 90–110 × 9–10 μ, and the ascospores, 13–17 × 6–8 μ.

Microcera coccophila Desm., "No. 1350, Plantes Cryptogames de France, Ed. II, Ser. 1, 1836–51," specimen in Herb. B.M., has synnemata flattened pulvinate or discoid, with a rather broad whitish margin, up to 0·6 mm. diameter, or conical, up to 0·6 mm. high, 0·3 mm. diameter below, or clavate, with erect fascicles of hyphae at the base; the sheath divides above into separate hyphae; the conidia are scanty, 50–80 × 5–6 μ, almost straight, fusoid, with obscure septa up to nine. This specimen also bears clustered perithecia on a well-developed stroma; the developing perithecia are orange, covered with fascicles of hyphae from the stroma; the mature perithecia are red; the ascospores are 12–18 × 5–7 μ.

Both Herb. B.M. and Herb. Kew have *Microcera coccophila* Desm., "No. 1750, Plantes Cryptogames de France, Ed. 1, Ser. 1, 1825–51"; this has some of the synnemata cylindric, up to 0·7 mm. high, 0·2 mm. diameter.

Conidial specimens from Penzance, the type locality of *Atractium flammeum* Berk. and Rav., when collected in later years, were referred correctly to *Microcera coccophila* Desm. In Herb. B.M., there are specimens *ex* Herb. Broome, *Microcera coccophila* Desm. (1) Trengwainton, Penzance, 14 Dec. 1869; (2) nr. Penzance, Dec. 1869; (3) Trengwainton, 4 Dec. 1869, marked "early stage of *Nectria Ralfsii*?." It is not related to *Nectria Ralfsii*. Specimen 1 shows the developing perithecia of *Sphaerostilbe flammea*. Herb. B.M. also has Cooke 350 and 534, and duplicates from Herb. Cooke.

Herb. Kew has, under *Microcera coccophila* Desm., a specimen *ex* Herb. Berkeley, marked "Penzance, C.E.B., Dec. 1869," containing minute synnemata on a well-developed stroma; Cooke, Fungi Brit. Exsicc., No. 350 (two examples); Cooke, Fungi

Brit. Exsicc., Ed. II, No. 534, C. E. Broome (two examples); and duplicates *ex* Herb. Cooke. Cooke's specimens are generally poor; some are not localised or dated; others are marked, "near Penzance, 14 December, 1869," "Penzance, Dec. 1869, C. E. Broome," and "Cornwall, Jan. 1870, C. E. Broome," respectively.

In the cover of *Myriangium Duriaei* in Herb. B.M., there is an undated specimen, marked "near Ryde, Isle of Wight, A.B." In addition to the *Myriangium*, this bears *Microcera coccophila*.

A specimen, *ex* Herb. Cooke, under *Microcera coccophila* Desm. in Herb. Kew, is marked "*Atractium coccigena* B. and C., Cort. Persicae, Ludoviciana." There is very little left of the fungus, but it is apparently *Microcera coccophila*. I am indebted to Mr Grove for the suggestion that the locality is Louisiana.

Of the specimens cited by Ellis and Everhart in "North American Pyrenomycetes" as *Sphaerostilbe coccophila* Tul., that on *Alnus serratula* from Pennsylvania is, as already stated, *Sphaerostilbe flammea*, while Ravenel, Fungi Americani, No. 286 is *Sphaerostilbe aurantiicola*.

Microcera pluriseptata Cke. and Massee was described in Grevillea, XVII, p. 43, as occurring on *Calocera* and bark, in Mexico. The type specimen in Herb. Kew was originally endorsed by Berkeley "Brazil, Cordova, Salle," but Cooke crossed out Brazil and substituted Mexico. The fungus is on a scale insect, and the supposed *Calocera* consists of the almost effete synnemata, which are up to 2·5 mm. high. The conidia are 75–90 × 5–7 μ, five- to seven-septate, but with somewhat obscure septa; they tend to collapse laterally. Perithecia occur on the scale insects and on the old synnemata; they are typical *Sphaerostilbe flammea*, with ascospores 13–17 × 7 μ, oval, pale yellow. *Microcera pluriseptata* Cke. and Massee is consequently a synonym of *Microcera coccophila* Desm.

Fusarium coccinellum (Kalch.) Thuem., *Fusisporium coccinellum* Kalch., was described by Kalchbrenner in Fungi Austro-Africani, Flora, LIX (1876), p. 426, and issued by de Thümen, Mycotheca Universalis, No. 782, the specimens being from the Cape of Good Hope. It is on a scale insect. In the specimens, Thuemen 782, in Herb. Kew and Herb. B.M., the synnemata are clavate, 1·25 mm. high, 0·25 mm. diameter below, expanding to 0·5 mm. diameter above, or shortly stalked, with flattened globose heads up to 0·75 mm. diameter, or sessile and pulvinate. The conidia are 74–80 × 5–6 μ, almost straight, or straight with falcate tips, or slightly curved, obscurely septate, with up to nine septa. As noted by Kalchbrenner, the base of some of the sessile forms swells strongly in water. The specimens were

collected by P. MacOwan at Somerset East, on *Acacia horrida*, the collection number being 1059. There is a part of this collection in Herb. Kew, "Kalchbrenner No. 1059, on *Acacia horrida*, Cape," determined by Cooke as *Sphaerostilbe flammea conidiophora*, while another part, also in Herb. Kew, is labelled in an unknown handwriting, "*Sphaerostilbe flammea* Tul., Cap. b. sp., leg. MacOwan, No. 1059, comm. $\frac{9}{83}$. Type of Kalchbrenner." Herb. Kew has also a specimen, *ex* Herb. MacOwan, marked "1064, *Nectria haematococca* B. and Br., ad corticem *Acaciae horridae*" which was also referred to *Sphaerostilbe flammea* by Cooke; it is the same as the other specimens and does not contain perithecia. No perithecia have been observed in this gathering, but it appears to be *Microcera coccophila* rather than *Microcera aurantiicola*.

In Herb. Kew, there are specimens, *sub Microcera coccophila*, from New Zealand—Rev. W. Colenso, B. 82, on bark of *Alectryon excelsum*; Colenso, B. 919; and Colenso, B. 727. These are large forms, with synnemata up to 2·25 mm. high, 0·6 mm. diameter. The conidia are 75–85 × 6 μ, straight with acute tips, or straight with slightly falcate tips, or slightly uniformly curved, up to nine-septate, with well-developed septa. No perithecia have been observed, but from the shape of the conidia, the specimens would appear to have been referred correctly to *Microcera coccophila*.

Herb. B.M. has the Australian specimen from Bailey, *ex* Herb. Broome, referred to by McAlpine under *Microcera coccophila*. It is marked, Brisbane, F. M. Bailey, No. 383, and contains well-developed synnemata on a scale insect on leaves and stem of Citrus. The conidia are 75–100 × 6 μ, up to nine-septate, with well-developed septa; some have falcate tips, but the majority are fusoid and straight. It would appear to be correctly named.

Sphaerostilbe aurantiicola (B. and Br.) Petch.

This species was described by Berkeley and Broome, as *Nectria aurantiicola*, in Fungi of Ceylon, No. 1028, their description being—"Peritheciis aurantiacis in stromate erecto sitis; ascis clavatis; sporidiis ellipticis uniseptatis, sporisque fusuloideis (No. 190). On orange twigs. Sporidia 15 μ long, 7·5 μ wide; spores fusiform, curved, multiseptate, 92 μ long; others triseptate and strongly curved, 20 μ long. Apparently growing from some Coccus."

The type specimen in Herb. Kew, *ex* Herb. Berkeley, is now very poor. Better specimens are to be found in Herb. British Museum, *ex* Herb. Broome. The following description has been drawn up from Ceylon specimens which agree with the types.

The synnemata arise from a narrow, yellowish-white, loose weft of hyphae at one side of, or surrounding, the scale. They are orange-red, or pinkish-red with a blood-red head, generally erect, clavate, expanding into an ovoid head (Plate III, fig. 1), or with a cylindrical stalk and a subglobose head, or uniformly cylindric. Small specimens are about 0·8 mm. high, 0·15 mm. diameter below, expanding into a head, 0·3 mm. diameter, but they may attain a height of 2 mm., with a stalk 0·4 mm. diameter and a head 0·6 mm. diameter. Several may arise from the same scale, and adjacent synnemata may fuse laterally into a broad band. The stalk is sometimes smooth, but more usually longitudinally fibrillose, especially at the base. When fresh, the fructification is subtranslucent: when dry, it is hard and horny, and, while the smaller specimens may retain the blood-red colour of the head, the larger become a nondescript brownish red or reddish yellow. Some specimens are almost sessile, clavate or ovoid. The head is often laterally compressed, and often hooked or produced laterally into a point.

The outer layer of the stalk hyphae forms a continuous sheath which divides above into long triangular teeth, about 120 μ long and 16 μ broad at the base. In small specimens, these teeth may converge at the apex of the head, but in the larger they are adherent to its sides. The outer sheath hyphae are about 4 μ diameter, equal, septate, and united by ladder connections. The interior stalk hyphae are continued above as branched conidiophores, 3 μ diameter, with long branches. Ladder connections are common between the bases of the conidiophores.

The conidia are cylindric, tapering towards the ends (Plate V, fig. 10), or long fusoid, straight, or slightly curved at the ends, hyaline, multiseptate. Under a low power they have a distinct yellow tinge. Up to eleven septa have been counted, but nine is more usual. The two ends of the spore are not equally curved; the distal end is slightly and uniformly curved and terminates in an obtuse point, while the proximal end is more falcately curved and more acute. A few uniformly curved conidia, of the same length, may sometimes be found. Measurements of the conidia from different gatherings are 88–110 × 6–7 μ; 90–116 × 6–7 μ; 80–112 × 6–7 μ; 84–104 × 7 μ; 96–120 × 5–6 μ; 90–120 × 6–7 μ; 70–92 × 5–6 μ.

In addition to the conidia described above, a smaller, more curved conidium (Plate V, fig. 11) is found in some gatherings. It was noted by Berkeley and Broome, and has been observed in five recent collections, including one from Dominica. It does not occur in the head with the long conidia, but on the looser mycelium at the base of the stalk. Sometimes it is found at the base of the perithecium, although there may be no conidial

fructification evident there under a magnification of forty diameters. This conidium is strongly curved, up to two-thirds of a circle, fusoid, hyaline, one- to three-septate, with obtuse tips, 12–16 × 4 μ, measured from tip to tip, not round the curve.

The perithecia (Plate III, fig. 3) are situated round the scale, scattered or clustered, with no evident stroma, but usually attached by a few inconspicuous radiating hyphae. As a rule, they occur round scales which do not bear the conidial synnemata. But, as noted by Berkeley and Broome, perithecia also occur at the base of the synnemata, or along their stalks, or even among the conidiophores in the head. This however only occurs on the larger synnemata, and even on those it is not the rule. I have only one collection in which this occurs, and in that the perithecia on the synnemata are immature. Parkin illustrates this position of the perithecia in his figure 9.

The perithecia are smooth, or pruinose with a few yellow granules, subsequently becoming smooth, very minutely rugose when highly magnified, 0·2–0·25 mm. diameter, subglobose, with a broad papillate ostiolum, or subconoid, scarcely papillate (Plate III, fig. 4). They are usually orange-red, becoming blood-red or dark red, and subtranslucent, but immature examples may be orange-yellow. The latter may account for Berkeley and Broome's "aurantiacis," but it is more probable that they gave the colour of the wall by transmitted light. In old examples, the wall, when mounted, is red-brown, but younger examples show an orange-yellow wall, though viewed as opaque objects they are orange-red. This is a common phenomenon in red Nectrias in the tropics. The cells of the perithecium wall are thick-walled and up to 12 μ diameter, though the structure is usually obscure. The ostiolum is fimbriate.

The asci are cylindrico-clavate, scarcely pedicellate, eight-spored, with diffluent paraphyses with granular contents. The spores may be uniseriate, or obliquely uniseriate, or obliquely uniseriate above and uniseriate below. The dimensions of the asci in different gatherings are 72–80 × 6–7 μ; 70–80 × 7 μ; 70–88 × 6 μ; 66–74 × 7–9 μ; 70–90 × 7–8 μ; 74–80 × 7 μ; 70–80 × 7–8 μ.

The ascospores are oval, or broadly oval, ends obtuse, hyaline, becoming yellowish, wall rather thick and minutely warted, one-septate, not constricted at the septum, except slightly in old extruded spores. Their dimensions in different collections are, 9–12 × 5–6 μ; 10–12 × 4–5 μ; 11–13 × 5 μ; 9–13 × 5–6 μ; 11–13 × 5–6 μ; 10–14 × 5–6 μ; 10–14 × 4–6 μ.

I have the following recent collections of this species. On *Diaspis pentagona* on *Flacourtia Ramontchi*, Ceylon. On *Aspidiotus aurantii* on Rose, Ceylon. On *Aspidiotus aurantii* on

Citrus, Ceylon. On *Aspidiotus aurantii* on Mulberry, Ceylon (five collections). On *Aspidiotus* sp. on *Cycas*, Ceylon. On a diaspid (?) on *Thespesia*, Ceylon. On *Mytilaspis citricola* on *Citrus*, Ceylon (three collections). On ? *Porococcus*, on Palmyra, Ceylon. On *Lepidosaphes* sp. on Pepper (*Piper nigrum*), South India (C. A. Barber, 1905). On *Lepidosaphes* sp. on *Citrus*, Madagascar. Conidial stage on *Aspidiotus* and *Lepidosaphes*, and perithecial stage on *Lepidosaphes*, on *Citrus*, Dominica.

In the specimen from Dominica, the synnemata are small, and the conidia measure only 70–92 × 5–6 μ: most of them are three-septate, a few five-septate. The asci are 74–80 × 7 μ, and the ascospores 10–14 × 4–6 μ. The perithecia are identical with the Ceylon form of *Nectria aurantiicola*, and the small, curved *Fusarium* spores occurred with them.

A *Sphaerostilbe*, parasitic on scale insects in Japan and Formosa, has been recorded, with some doubt, by Miyabe and Sawada, as *Sphaerostilbe coccophila* Tul. I have been able to examine the following specimens, *ex* Herb. Sapporo.

On a scale on apple trees, Tsukisappu near Sapporo, October 5, 1907. In this, some synnemata are suberect, with a short stout stalk, 0·2 mm. diameter and 0·4 mm. high, expanding into an ovoid head, 0·3 mm. diameter, and 0·4 mm. high, pointed above; the stalk in these is dark red, subtranslucent, and the head pale yellowish, the latter colour being due to the disappearance of most of the conidia. Other synnemata are almost sessile, ovoid, or sometimes merely pulvinate, dark red. The sheath divides above into teeth, but the teeth break up above into separate hyphae, as a rule, as long as, or longer than, the conidiophores. The conidia measure 84–100 × 5–7 μ, and are up to nine-septate, nearly straight or curved at the tips, one end more obtuse than the other. When examined under a low power the conidia are distinctly yellowish.

In another gathering, on a coccid on *Ficus Wightiana*, Sozan, Formosa, May 1911, the synnemata are mostly stalked, but the heads have been eaten off by insects.

In a collection, on coccids on *Citrus nobilis*, Shimpo, Formosa, May 7, 1910, the synnemata are generally small, pulvinate, blood-red masses at the side of the scale, sometimes several confluent and forming a fringe at one end.

Similar synnemata occur on scale insects on *Citrus nobilis*, Taihoku, Formosa, April 25, 1911. Some of the sessile pulvinate synnemata are up to 0·4 mm. long and 0·2 mm. broad. Stalked forms, with stalks up to 0·3 mm. high and 0·2 mm. diameter, also occur in this gathering. The conidia are 80–96 × 6–7 μ.

Perithecia appear to be rare in the Formosan collections. Miyabe and Sawada state that they have only found them once,

on Tea, Taïhoku, Sozan, May 1911. I have seen a leaf of that gathering, which bore one perithecium, not quite mature. It was subconoid, 0·15 mm. diameter, orange-red, slightly pruinose with yellow granules, seated on the scale without any evident stroma. No mature asci were found, but two loose ascospores were observed, measuring $10 \times 3\,\mu$ and $12 \times 5\,\mu$ respectively; Miyabe and Sawada state that the ascospores measure $8–10 \times 4–5\,\mu$.

On the available specimens, the Japanese and Formosan forms would appear to be referable to *Sphaerostilbe aurantiicola*.

In Herb. British Museum, there are the following specimens from Florida, communicated by E. W. Berger;—(1) on *Aspidiotus perniciosus*, San José Scale, on Peach, all conidial; (2) on *Chrysomphalus aonidium*, Florida Red Scale of Citrus, on *Citrus*, two conidial specimens; (3) on *Lepidosaphes beckii*, Purple Scale of Citrus, one specimen containing the conidial stage and scattered perithecia with ascospores $10–13 \times 5–6\,\mu$.

As pointed out under *Sphaerostilbe coccophila*, the specimens collected at Florence in 1860, which furnished the perithecial examples of that species are *Sphaerostilbe aurantiicola*. These are represented in British herbaria by the following.

"No. 262, Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda. *Nectria episphaeria* Tode. Ad *Lauri* corticem in horto Boboli Florentiae, Majo 1860, leg. L. Caldesi." Specimens in Herb. Kew and Herb. B.M. The bark is densely covered with scale insects. The perithecia are usually scattered without evident stroma, sometimes clustered, orange-red becoming dark red, conoid, usually collapsing laterally; apex darker, conical, or papillate; asci $65–75 \times 7\,\mu$; ascospores $9–14 \times 4–5\,\mu$; perithecial wall red-brown by transmitted light. Small curved triseptate spore rather common, $14–18 \times 3–3{\cdot}5\,\mu$. Synnemata appear to be absent.

"No. 269, Rabenhorst, Fungi Europaei Exsicc., Ed. nov., Ser. secunda. *Microcera coccophila* Desm. Florence, ad corticem *Lauri* in horto Boboli dicta, Majo 1860, leg. L. Caldesi." Specimens in Herb. Kew and Herb. B.M. A poor development on scattered scale insects. Synnemata pulvinate; conidia $75–85 \times 6\,\mu$, few in comparison with the number of conidiophores; septa up to nine, but usually few and obscure. Perithecia immature, orange-red, subtranslucent, scattered or in small clusters, wall yellow when mounted.

"No. 543, Erbar. Crittogam. Ital., *Microceras coccophila* Desm., Sull' Alloro nel giardino di Boboli a Firenze, Aprile 1860, Caldesi." Specimen in Herb. B.M.; resembles Rabenhorst 262, and Erbar. Crittogam. Ital. 539; contains chiefly developing *Nectria*. Synnemata flattened pulvinate, circular, 0·4 mm. diameter, or clavate, 0·75 mm. high, 0·25 mm. diameter; conidia scanty,

80 × 6 μ, almost straight with one end falcate, or slightly curved.

"No. 539, Erbar. Crittogam. Ital., *Nectria episphaeria* Fr., Sull' Alloro nel giardino di Boboli a Firenze, Maggio 1860, Caldesi." Specimen in Herb. B.M. ? same collection as Rabenhorst 262. Apparently no synnemata. Small curved *Fusarium* spore present, 18 × 3·5 μ. Perithecial wall red-brown when mounted; ascospores 10–12 × 4 μ.

The foregoing are apparently all parts of the same growth of the fungus. Another collection was made in the same locality six years later, "No. 542, Erbar. Crittogam. Ital., Ser. II, *Sphaerostilbe coccophila* Tul., Sull' Alloro nel giardino di Boboli a Firenze, 1866, Caldesi," of which there is a specimen in Herb. B.M. A narrow, yellowish byssoid stroma surrounds the scale. The synnemata are flattened pulvinate, up to 0·6 mm. long, 0·4 mm. broad, and 0·2–0·3 mm. thick, flesh-coloured, with a narrow white or yellowish tomentose margin, or erect, subcylindric or clavate, up to 0·75 mm. high, 0·3 mm. diameter; few conidia are present, and these are found among the conidiophores; the conidia are nearly straight with slightly falcate tips, 60–75 × 5–6 μ, up to seven-septate, with obscure septa: some conidia are strongly guttulate. On one effete cylindric synnema, the sheath persisted as a hyaline membrane. The immature perithecia are orange-red, mature perithecia red; they are situated in small groups on the marginal stroma, or sometimes on the synnemata; the ascospores are 9–12 × 4–5, a few 14–15 × 6 μ. The short curved *Fusarium* spore is present.

In Herb. Kew and Herb. B.M., there are American specimens *ex* Herb. Ravenel, under *Microcera coccophila*, "No. 2512, in corticis Mori, Darien, Georgia." This gathering appears to be the same as "No. 286, H. W. Ravenel, Fungi Amer. Exsicc., *Microcera coccophila* Desm. in corticis *Mori*, Darien, Georgia," of which there is a specimen in Herb. B.M. The synnemata are clavate, up to 1 mm. high, 0·4 mm. diameter, or flattened pulvinate, up to 1 mm. long and 0·6 mm. broad; the conidia are 56–80 × 5–6 μ, obscurely septate, with a few irregularly-arranged septa. The small curved *Fusarium* spore, 18 × 3 μ, is present. The ascospores are 9–12 × 4–5 μ. This specimen is *Sphaerostilbe aurantiicola*.

Sphaerostilbe coccidophthora (Zimm.) Petch.

This species was described by Zimmermann, as *Nectria coccidophthora*, from specimens on *Lepidosaphes* sp. on *Coffee arabica*, and on *Parlatoria zizyphi* on *Citrus*, found at Buitenzorg, Java. The following are the main details of his description.

The conidial fructification was scarlet (mennig-rot), shortly stalked, and swelled considerably in water. The stalk was 0·3–0·4 mm. long, and the head, 0·4–0·45 mm. long. The

conidia were surrounded by hairs, which were united laterally by ladder connections and converged above. The conidia were hyaline, cylindric, slightly curved at the tips, six- to eight-septate, 110–120 × 6 μ.

The perithecia were clustered at the base of the conidial fructification, or scattered over the stroma which permeates the insect. They were globose, carmine-red, with a papillate, somewhat paler ostiolum, 280 μ high and 230 μ diameter. The asci were eight-spored, 100 μ long. The spores were one-septate, hyaline, obtuse, not constricted, 17–20 × 7–8 μ.

Zimmermann compared his species to *Nectria aurantiicola* B. and Br., from which he decided it differed in the colour of the perithecia, and the form of the conidial fructification, according to the figures given by Berkeley and Broome. His figure of the conidia shows spores of the *Microcera* type, not *Pseudomicrocera*.

The only other record of this species appears to be that of Parkin, who assigned all the Ceylon *Microcera* forms to *Nectria coccidophthora*. Parkin's measurements of asci and ascospores appear to be from specimens of *Nectria coccidophthora*, but his figures of synnemata and conidia (9, 10, 11) are *Nectria aurantiicola*. Of Parkin's specimens which are now available, that on *Chionaspis biclavis* on *Tabernaemontana* is *Nectria coccidophthora*, and probably that on *Asterolecanium miliaris* on Bamboo, while, from his description, that on *Chionaspis biclavis* on Tea was the same species.

I have collections of what appears to be undoubtedly this species, on *Chionaspis biclavis* on Tea, Ceylon (two gatherings), on *Chionaspis* on an undetermined host plant, Ceylon (two gatherings), on *Chionaspis biclavis* on *Tabernaemontana*, Ceylon (Parkin's specimen), on *Chionaspis*, on an undetermined host plant, India (E. J. Butler), and on *Diaspis pentagona* on *Flacourtia*, Seychelles. It is noteworthy that, of the seven collections six are on *Chionaspis*.

The synnemata arise from a narrow, yellowish-white, loose, floccose stroma, or weft of hyphae, round the scale. They are orange-red or scarlet, paler towards the base, generally erect, usually clavate, expanding into an ovoid head. As a rule, they are not as stout as those of *Nectria aurantiicola*, being commonly about 0·8 mm. high, with a stalk 0·15 mm. diameter, and a head 0·3 mm. diameter, but sometimes examples occur which attain a height of 1·4 mm., and a stalk diameter of 0·25 mm. The stalk is generally longitudinally fibrillose. When fresh, the synnemata are subtranslucent, and become hard and horny when dry. Specimens in which the stalk is almost wanting are not uncommon; these may be ovoid, or conical, about 0·4 mm. high, and 0·25 mm. diameter. As in *Nectria aurantiicola*, the head is often curved to one side. The structure of the synne-

mata is identical with that of *Nectria aurantiicola*. The small, curved, *Fusarium* spores which occur in the latter have not been observed in *Nectria coccidophthora*, nor have developing perithecia been observed on its stalk above the base.

The conidia are cylindric, or long fusoid, almost straight, slightly curved at the ends, hyaline, multiseptate. Up to eleven septa have been counted, but the most common numbers are six to nine. In the usual gathering, however, large numbers of immature, unseptate conidia are met with. In shape, they agree with those of *Sphaerostilbe aurantiicola*, but the tips are sometimes slightly more curved. Septation begins at the distal end, and it is not uncommon to find conidia which have developed two or three consecutive septa at that end, before any are visible elsewhere. Measurements of the conidia from the different collections gave the following dimensions: 76–93 × 6 μ; one 62 × 6 μ; 78–96 × 6–7 μ; 88–98 × 6 μ; 88–106 × 6–7 μ; the total variation is 62–106 × 6–7 μ. The conidia agree in shape with Zimmermann's figure, but I have not met with any 110–120 μ long. In the available collections, the conidia of *Sphaerostilbe aurantiicola* usually attain a greater maximum length than those of this species.

The perithecia may be scattered, or clustered in groups up to ten. They are sometimes situated at the bases of the synnemata, but in general they are found on scales which do not bear any conidial fructification. They may be seated on a narrow floccose stroma round the scale, or the stroma may completely cover the scale, and the perithecia may be scattered over it. On the other hand, they may arise at the margin of the scale without any visible stroma.

The perithecia are subglobose or subconoid, 0·2–0·3 mm. diameter, collapsing laterally, orange-red at first, becoming blood-red, subtranslucent, covered with minute yellow, or yellowish-red, granules except round the ostiolum (Plate III, fig. 6). Weathered specimens lose the granular covering, and are blood-red to dark red, but when magnified the area round the ostiolum is evidently smoother than the rest of the wall. The shape of the ostiolum is highly variable: as a rule, it is slightly papillate, with a flat papilla about 60 μ diameter, but in some specimens the apex is merely obtusely conical. In one gathering, on *Chionaspis*, a few of the perithecia have the ostiolum produced and cylindrical, up to 96 μ high and 106 μ diameter, but in other examples on the one scale they are simply slightly papillate. This variation makes it impossible to separate the scale insect Sphaerostilbes on the shape of the ostiolum. The wall, viewed by transmitted light, is orange-yellow in immature, or young, examples, but red-brown in old specimens. The structure is generally obscure, but in some cases thick-walled

cells, up to 10 μ diameter can be recognised. The wall bears projecting cells, or one-septate processes, sometimes growing from the cells of the wall, and sometimes appearing to be merely fastened to it by a yellow substance. The ostiolum is fimbriate. When detached, the perithecium usually has a minute, and somewhat compact, mass of mycelium at the base.

The asci are cylindrico-clavate, i.e. cylindric, slightly attenuated below, and usually shortly pedicellate. They are accompanied by long, linear paraphyses, which disappear before the asci are mature; the paraphyses have granular contents. The asci are eight-spored, and the spores slightly obliquely uniseriate. Measurements of the asci from different collections gave 105–115 × 9–10 μ; 100–106 × 10 μ; 100–110 × 10 μ; 116–136 × 10 μ; 84–102 × 8 μ.

The ascospores are oval, or broadly oval, one-septate, thick-walled, ends obtuse, hyaline, becoming yellowish, not constricted at the septum, wall minutely warted, 13–22 × 7–9 μ. Measurements from different gatherings are 17–20 × 8–9 μ, one 14 × 6 μ, another 16 × 5 μ (old spores; asci not present); 14–20 × 7–9 μ, a few 17–18 × 6 μ; 13–16 × 8–9 μ, with some, in the ascus, globose, continuous, thick-walled, 9–10 μ diameter; 13–18 × 7–9 μ, one 16 × 5 μ; 16–22 × 8–9 μ. The specimen on *Chionaspis biclavis* on *Tabernaemontana* has spores 14–17 × 6–7 μ, in asci 84–102 × 8 μ, but in all other respects it does not differ from the other gatherings.

Parkin recorded a *Nectria* on *Asterolecanium miliaris* on Bamboo which he considered different from *Nectria coccidophthora*. The available perithecia on this specimen are immature, but they resemble those of *Nectria coccidophthora*, in being covered with yellow granules. From one old weathered perithecium, however, spores, some of them germinating, were obtained, which measured 21–27 × 9–10 μ. They are oval, somewhat attenuated towards one end, slightly constricted, pale yellow, thick-walled, with the wall minutely warted. Parkin describes them as elliptical and somewhat pointed, 22–27 × 9–10 μ, and the ascus as 115 × 13·5 μ. He also records that the conidia, which are not now present, measured 100–110 × 5·5–7·5 μ. The constriction of the ascospores may be disregarded, as extruded *Nectria* spores frequently swell, so that they become constricted at the septum, but the dimensions of the spores are greater than anything observed in *Nectria coccidophthora*. The specimen, however, is not now in good condition, and, provisionally, I would refer it to *Nectria coccidophthora* on the general characters of the perithecium.

(To be continued in next part.)

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